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Evaluation of the Economic, Social and Environmental Effects of Floodplain Regulations

federal emergency
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federal insurance administration

THE CONTENTS OF THIS REPORT REFLECT THE VIEWS OF THE CONTRACTOR WHO IS RESPONSIBLE FOR THE FACTS AND THE ACCURACY OF THE DATA PRESENTED HEREIN, AND DO NOT NECESSARILY REFLECT THE OFFICIAL VIEWS OR POLICIES OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT OR THE FEDERAL EMERGENCY MANAGEMENT AGENCY.

Evaluation of the Economics, Social and Environmental Effects of Floodplain Regulations

U.S. Department of Housing and Urban Development
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FOREWORD

Ninety percent of the natural disasters in this country are flood related. These costs have continued to escalate dramatically with the increasing development of flood plain areas. While man has always tended to locate near the water's edge, this tendency becomes a major problem as buildings rapidly spring up along the beaches and rivers of our nation.

This study, which tests the hypothesis that adoption of flood plain management regulations can reduce flood losses and generally benefit the communities practicing effective land use management, points out that through the adoption of flood plain management regulations we can dramatically reduce the current costs of flood disasters and relief and stop the escalating price that this nation is paying. It is a warning that must be heeded if property and lives are to be saved.

While this study does not specifically discuss the Federal Insurance Administration or the National Flood Insurance Program, it does indicate that the basic premise of that program — that effective flood plain management can reduce the high cost of flood hazard losses -- is valid. This was the premise upon which Congress based the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973, as amended. As a requirement for qualifying for flood insurance protection, a community must adopt and enforce effective flood plain management regulations to safeguard their citizens and reduce future flood losses. This quid pro quo was built into the program as a means of encouraging State and local governments to manage their flood plain areas in ways that will protect as well as add to the well-being of their citizens.

In implementing the National Flood Insurance Program, the Federal Insurance Administration has worked to inform local communities of the flood hazards in their respective regions and advise local officials of the minimal protective safeguards required. FIA has been accelerating its work with communities taking steps to reduce their vulnerability to flood hazards. When flood losses occur, despite mitigation efforts, FIA's flood insurance policies can provide economic recovery for those families and businesses that experience losses. Mitigation of these hazards and development of an actuarially sound insurance program are ways in which the Federal government is helping to reduce the national flood disaster and relief costs.

Richard W. Krimm
Acting Administrator
Federal Insurance Administration

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ABSTRACT

This study evaluates quantitatively the economic, social and environmental effects of regulating the 100-year floodplain. Twenty-three case study communities were selected for analysis according to different locations, flood hazard types, community sizes, and economic conditions.

Effects of Flood plain regulations were evaluated by projecting development for 1980 and 1990 under three regulatory scenarios: (1) no regulations, allowing the free market to determine the 100-year floodplain use; (2) moderate regulations similar to the current FIA regulations; and (3) stringent regulations forbidding new development and substantial improvements to existing structures and "correcting" past land use decisions which interfere with natural functions of the 100-year floodplain.

Economic Effects

When no regulations are applied, average annual flood losses increase sharply (29% by 1980; 71% by 1990). Under moderate regulations, the losses in Scenario I would be decreased by 87% in 1980, and by 85% in 1990. Regulations that prevent development produce a small, but measurable absolute decline in average annual flood losses (1% by 1990).

Social Effects

With no regulations, the total number of housing units in the 100-year floodplain would increase 13% by 1980 and 35% by 1990; population would increase in the 100-year floodplain 12% by 1980 and 29% by 1990.

With moderate regulations, this increase in housing would be reduced by 37% in 1980 and by 78% by 1990; the increase in population would be decreased by 43% in 1980 and 41% in 1990. With stringent regulations, housing units in the 100-year floodplain would decline 1% by 1980 and 6% by 1990.

Environmental Effects

With no regulations there would be a continuing, unlimited conversion of floodplain open land to urban uses and additional 37% by 1990. Moderate regulations would reduce this increase by 36% by 1990. Stringent regulations would not allow any further development of the floodplain, would begin to remove existing development, and would result in a 2% reduction of developed acres.

The study shows that moderate regulations will greatly reduce the rate of increase of flood losses, but will not produce a decline of such losses. If the corrective elements of Scenerio III are added to the moderate regulations, it is probable that the effects would closely approach the absolute decline resulting from stringent regulations. Such a program would allow communities to achieve their comprehensive community development goals, which allow them to reduce their flood losses. It would also reduce national flood losses, as envisioned in Federal legislation since 1936.

CHAPTER I

EXECUTIVE SUMMARY WITH FINDINGS AND CONCLUSIONS

Average annual flood losses have continued to increase in the United States during the last forty years. A Federal investment of $10 billion in structural flood control works (levees, channel improvements, multipurpose reservoirs, etc.) had not achieved a reduction. In 1975 the Water Resources Council estimated total average annual flood damages in 1975 at $3.6 billion, $1.2 billion of which were urban flood losses.[1]

Escalating flood losses have made it increasingly evident that a national effort that relied solely on structural measures to reduce flood losses was inadequate. A unified program that employed the full range of floodplain management measures including floodplain regulations was deemed necessary. Federal initiatives in a unified program include: the National Flood Insurance Program (NFIP); the Corps of Engineers regulations ER-1120-2-117 with its emphasis on floodplain management; Section 73 of the Water Resources Development Act of 1974 requiring nonstructural considerations; Section 406 of the Disaster Relief Act of 1974, stating communities must take certain flood damage mitigation actions as a prerequisite for Federal disaster assistance; and Executive Orders 11296 and subsequently 11988 requiring Federal agencies to consider floodplain management.[1]

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[1] Water Resources Council, Estimated Flood Damages, 1975-2000-Appendix B: Nationwide Report (Washington, D.C.: Water Resources Council, 1977) p. 2. The reported 1977 figure for national average annual losses is $3.8 billion. Using the method of adjustment adopted in this study, the figure is deflated to $3.6 billion in 1975.

These actions directed attention to the use of floodplain regulations to reduce flood losses. Rapid expansion of floodplain regulatory activity has led to varied speculation concerning economic, social and environmental effects of such regulations. The extent of community adoption of floodplain regulations suggests that such regulations are addressing perceived needs. On the other hand, the resistance of some communities to the adoption of floodplain regulations suggests adverse effects. To establish what the actual effects of regulations are, empirical data on the economic, social, and environmental effects of floodplain regulations must be gathered. An analysis of past research efforts showed several attempts were undertaken to measure the economic, social, and environmental effects of flooding. However, no research efforts were identified that attempted to evaluate in a systematic manner the economic, social, and environmental effects of floodplain regulations on a national scale. Thus, it was necessary to gather empirical data in field investigations to qualitatively and quantitatively evaluate the effects of regulating the 100-year floodplain.[2]

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[1] For Corps of Engineers regulations ER-1120-2-117, see: Office of the Chief of Engineers, "Investigation, Planning and Development of Water Resources: Alternatives in Flood Related Planning" (Washington, D.C.: August 17, 1970); Executive Order 11296 is entitled: "Evaluation of Flood Hazards in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities, and Disposing of Federal Lands and Properties" (August 10, 1966); Executive Order 11988 is entitled: "Floodplain Management" (May 24, 1977, issued in 42 FR 101, May 25, 1977).

[2] See Glossary (pages 167 & 168) for definitions of 100-year floodplain and other selected or uncommon terms used in this report. Others are not individually referenced.

Scope of Research and Methodology

The research began with a four phase effort to identify potential effects of floodplain regulations. The candidate effects were gleaned from Congressional hearings records, expert opinion, an assessment of the results of court decisions relating to floodplain regulations, and floodplain management literature. From these sources, a comprehensive list of potential effects of floodplain regulations was compiled (Figure 1). These potential effects were then classified whenever possible, under the headings of economic, social, and environmental effects. Further review and screening of the potential effects produced a listing of selected effects to be evaluated.

A case study approach was used to evaluate the selected effects. A total of 23 case studies were visited during the research. However, only data from 21 were included in the evaluation tables. The data collected for San Diego County, CA were not of comparable detail with other case studies and therefore could not be included in the evaluation tables with the exception of the one dealing with regulatory characteristics. The data for Bergen County, NJ and its 71 local governments were gathered after the initial analyses for the other case studies were completed.[1] The thrust of the Bergen County effort focused on the financial implications of floodplain locations and regulations. These data are more detailed than those gathered in the other case studies and could not be synthesized readily into the analyses.

The 21 case studies which form the basis for this evaluation of effects are in the National Flood Insurance Program (NFIP) and

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[1] Sixty-seven municipalities and the Hackensack Meadowlands entity participated in the NFIP; 3 local governments did not.

Figure 1: Screening of Identified Effects

CLASSIFIED EFFECTS	SCREENING STEPS	EFFCTS EVALUATED
ECONOMIC Flood Damages Protect property from damage/reduce damages residential business (commercial/industrial) non-profit private property public facilities -buildings -roads, bridges -utilities -sewers -recreation Will not protect property from catastrophic flood damages Disruption Losses Protect against employment and income losses Protect against disruption in the production of goods Protect against disruption in the provision of commercial services Reduce Property Value/Marketability Reduce anticipated profits Loss in property equity Reduce assessments and property taxes for occupants of hazard area Maintain/preserve intrinsic economic value of property Economic Effects on the Community Divert/deter development from community Loss of jobs/industry Loss of tax base Not divert development from community—will contain development in community Protection of tax base Cost of Compliance Increase cost of construction Increase cost of local government administration Cost for relocating urban infrastructure Reduce need for structural flood control expenditures Reduce disaster aid expenditures for Evacuation Relief	SCREEN NO. 1: IDENTIFIED EFFECTS NOT MEASURABLE SCREEN NO. 2: DATA BASE INCOMPLETE OR NONEXISTENT SCEEN NO. 3: AVAILABLE DATA TOO GENERAL FOR ANALYSIS OF SPECIFIC EFFECTS SCREEN NO. 4: DATA REQUIREMENTS TOO EXTENSIVE FOR SCOPE OF STUDY	ECONOMIC Flood Losses* (damages and disruption) Residential Business Non-profit/institutional *accounts for residual damages attributable to low-probability events Property Value Effect on anticipated profits (wind falls, wipe outs) Effect on marketability/transfer of real property Effects on assessments and property taxes for occupants of hazard area Economic Effects on the Community Effect on total community development -population -housing units -other development Effect on property tax base Cost of Compliance Effect of flood proofing on cost of construction
SOCIAL Shift Burden Shift burden from general public to occupants of hazard area Reduce disaster aid for rehabilitation and reconstruction Effects are Inequitable Burden falls disproportionately on the disadvantaged (who are disproportionate occupants of the hazard area) Discriminates against small communities (which cannot afford flood control works) Removes segment of population from housing market Divert development from hazard area Protect lives Disincentive to rehabilitation/deterioration of housing, neighborhoods Protect public infrastructure in total system from disruption Protect against disruption of public services (e.g., assessment, etc.) Maintain/preserve recreation value of open space		SOCIAL Shift Burden: effect on disaster aid payments for rehabilitation & reconstruction Inequity: characteristics of existing hazard area occupants (income, dependency, housing quality, minorities) Effect on Development in Hazard Area Housing units Other develpment Protect Lives Effect on population in the hazard area Effect on population-at-risk Effect on rehabilitation/effect on deterioration of housing stock, neighborhoods Effect on public services (e.g., assessments) Effect on open space recreation opportunities
ENVIRONMENTAL Land Use Changes Change land use pattern Divert development to edge of hazard area Maintain/preserve open space Maintain/Preserve Environmental Value of Open Space Groundwater recharge Storage capacity/stormwater detention Water quality Air quality Natural wildlife areas, fisheries Ecosystem quality)plant and animal life) -wetlands -marshes -estuaries -coastlines -wild rivers Hydrology/Flooding Avoid rising flood stages Reduce drainage problems Reduce downstream flooding Not increase storage capacity profoundly Not reduce runoff problems profoundly (due to unregulated urbanization)		ENVIRONMENTAL Land Use: affect on open space in hazard area Preservation of environmental value of open space Hydrology/Flooding Effect on flood stages Effect on downstream flooding Effect on storage capacity

represent a range in population, area, flood type, and geographic location. Table 1 tabulates these characteristics. Population growth rates in the case study areas were higher than the national rates of growth. This indicates that there are development pressures in the case study areas and that floodplain regulations have the potential to affect future development. If the case study areas would have been remotely located static communities, the effects of floodplain regulation would be small.

Prior to the field visits to the case study areas, census material, aerial photos, and flood hazard information were assembled and evaluated. During the field visit this information was supplemented by data extracted from records, files, reports, and by direct observations. Information gathered in the field related to: community goals; social, economic, and environmental characteristics; trends in development patterns; growth trends; land use patterns and pressures; the perception of the flood risk; the extent and character of flood damages; the history of adjustments to floods; and the evolution of floodplain policies, including attitudes toward structural flood control measures. In addition, assessments of land use changes over time were made to gain insights into the compatibility of actual development decisions and articulated development policies.

Interviews were held in each study area with a panel of community informants and identified community influentials.[1] Included among the community informants and influentials were mayors, city managers, tax assessors, planners, zoning administrators, building inspectors, bankers, realtors, builders, floodplain residents, newspaper editors, and representatives of voluntary organi-

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[1] Terry N. Clark, Community Structure and Decision Making: Comparative Analyses (San Francisco: Chandler Publishing Company, 1968) pp. 471-473.

Table 1: Physical and Regulatory Characteristics of Case Study Communities

Case Study Communities	NFIP		FLOOD HAZARD TYPE				TYPE OF REGULATION							
			Coastal		Riverine									
	Status	Date	Hurricane	Other	Flash	Slow	Sub Regs	Bldg Code	Bldg Pmts	Elev Reg	Density Transfer	Reg Flway	St. Regs	Zon. Type
Cranston, RI	R	10/11/70	X			X	X	X	X	0				z
Westerly, RI	R	7/28/73	X					X	X	+2				0
Northampton, MA	E	5/31/74				X				0			yes	0
Wayne Township, NJ	R	2/20/73			X	X	X		X	0	PUD	X	yes	0
Southampton Town, NY	R	9/28/73	X					X	X	+2/+4			yes	
Jersey Shore, PA	R	4/6/73				X		X	X	0		X	yes	0
Wheeling, WV	E	4/21/76			X	X								
Prince Geo.Co.,MD	R	3/4/72				X	X	X	X	0	X	X	yes	
Savannah, GA	R	5/21/71	X			X	X			+1/2				
Sarasota Co., FL	R	7/31/71	X			X	X	X	X	0				0
Toledo, OH	E	12/18/70		X		X	X		X				yes	0
Palatine, IL	R	2/20/73				X	X	X	X	+1	X		yes	z
Prairie du Chien, WI	R	5/22/70				X	X		X	+2		X	yes	z
Orleans Parish, LA	R	10/19/71	X				X	X	X	0				0
Tulsa, OK	R	11/20/70			X									
Harris County, TX	R	5/26/70	X		X				X	0				0
Cape Girardeau, MO	E	5/31/74			X	X			X					z
Omaha Area, NB	R	5/8/71			X		X	X	X	+1		X	yes	z
Fargo, ND	R	4/10/70				X	X	X	X			X		0
Arvada, CO	R	7/13/72			X			X	X	+2	X	X	yes	0
Scottsdale, AZ	R	9/21/73			X				X	above	X	X		z
San Diego Co., CA	E	3/5/71		X	X		X	X	X	above		X	yes	0
Total Sample	-	-	7	2	9	13	12	12	18	-	5	9	11	-

E=Emergercy Program; R=Regular Program
Elevation above the 100-year flood level in feet
z=Floodplain zone; O=Overlay zoning district

zations with known interests in floodplain regulations. A purpose of the interviews was to elicit views on community goals, policies, and problems which have the potential to affect floodplain management.

Current Conditions in the Case Study Areas

Current conditions in the case study areas were similar to assessments of the flood hazards in other urban areas. The 100-year floodplain in the case study areas constituted 20 percent of the total land area. The 100-year floodplains were 18 percent developed, in contrast to the areas outside those floodplains which were 29 percent developed. This difference suggests that the perception of the flood hazard has had some influence on the development pattern. Perhaps more importantly, it shows the need for preventing further unwise use of the floodplain.

According to data obtained from the case study areas, approximately 14 percent of the case study area population, and 13 percent of housing is in the 100-year floodplain. However, because of the existence of units elevated above grade and multi-story structures, approximately 7 percent of all dwellings and 8 percent of the population are actually at risk from the 100-year flood event.

The floodplains in the study area contain a low percentage of nonwhite population; half the percentage found in nonhazard areas. However, dependent population was nearly 7 percent higher in the floodplain than in the nonhazard area. Household size in the floodplain was 2 percent greater than that of the total study area; household size at risk averaged 5 percent larger. The mean

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[1] James E. Goddard, An Evaluation of Urban Floodplains, American Society of Civil Engineers Technical Memorandum No. 19 (New York: American Society of Civil Engineers, 1973).

income of families and individuals occupying floodplains was 5 percent lower than those of the nonhazard areas. The local difference could well be greater because this figure includes several communities where sites with direct access to the water bring a premium.

Census Block data, which were available for only 13 case studies, indicated that the value of housing tended to be somewhat lower in the floodplain than in the nonhazard areas, particularly for riverine locations. On the other hand, single family housing and owner-occupied housing was more prevalent in the floodplain. A higher vacancy rate existed in the floodplain along with higher percentages of older and substandard housing.

Average annual flood losses for the case study communities were estimated at $76.6 million. This estimate was based on available data from the Corps of Engineers and the Soil Conservation Service. More than 52 percent of the losses was to residential development. Commercial and industrial development accounted for 32 percent. Public uses were estimated to experience 16 percent of the losses. The largest case study areas (Harris County and Orleans Parish) comprised 48 percent of the total floodplain area represented in the case studies, but accounted for 64 percent of the flood losses.

A detailed analysis of the effects of regulations on property values was beyond the scope of this study. However, based on limited available data in the literature and an analysis in one case study area, market values do not appear to be depressed by the enforcement of existing floodplain regulations.

The influence of floodplain regulations on market values of floodplain property can be viewed from either the perspective of the effects on developed property or the effects on undeveloped property. With respect to developed property, floodplain regulations exist along with many other regulations and codes which relate to the property. The existing structures are "grandfathered" in (becoming nonconforming uses) and thus do not have to comply with the regulations and codes unless they require substantial improvements. However, the application of substantial improvement regulations to remove nonconforming uses has not been widespread nor effective.[1] Thus, the effects on market property values would be slight.

The greatest potential for floodplain regulations to affect market property values relates to changes in land use, e.g., change from undeveloped to developed land or from single family residential uses to higher intensity uses such as shopping centers or high rise apartment buildings. If such desired changes are prevented by floodplain regulations, anticipated windfall profits associated with such transactions may not be realized. However, it is important to note that windfall profits associated with land speculation frequently are not realized independent of any regulations.

Compliance with the existing floodplain regulations did not appear to be a deterrent to development in the floodplains of case study communities. Development projects that were believed to be economically feasible were constructed in accordance with the provisions of the floodplain regulations. In a special analysis of flood proofing alternatives on a proposed small commercial building in Jersey Shore, Pennsylvania, it was shown that construction costs would increase between 6 and 16 percent to flood proof to the 100-year flood elevation.[2] However, these increased costs of flood proofing were determined to be more than offset by anticpated reductions in either future flood losses or insurance costs. An analysis of flood proofing in Canada showed similar results.[1]

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[1] Sheaffer & Roland, Inc., Alternatives for Implementing Substantial Improvement Definitions (Washington, D. C.: Department of Housing and Urban Development, Federal Insurance Administration, 1978).

[2] Sheaffer & Roland, Inc., Economic Feasibility of Flood Proofing: An Analysis of a Small Commercial Building (Washington, D.C.: Department of Housing and Urban Development, 1978).

A separate study of the substantial improvement provisions of floodplain regulations showed they did not have any significant effects.[2] At the existing threshold of 50 percent of market values, it was estimated that the total number of residential structures substantially improved each year would not exceed 13,600 nationwide. Of this total only an estimated 4,200 or 30 percent would result from natural disasters.

Projected Effects In Case Study Areas

A scenario method was used to forecast development conditions in the near (1980) and longer term (1990) future for specific areas under three sets of regulatory conditions. These conditions are presented as three regulatory scenarios.

Projections of population and future land use patterns were made for each case study area from the information gathered during the field investigations. These projections provided the basis for the forecasts of population, housing, and developed areas (land use) that were formulated for 1980 and 1990 target years under the three regulatory scenarios. Differences between the scenarios were taken to be indicators of the effects of different degrees of floodplain regulations.

The three scenarios are comprised of (1) allowing the free market to determine the 100-year floodplain use with no regulations

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[1] James F. McLaren, Ltd., Flood Proofing: A Component of Flood Damage Reduction (Ottawa, Canada: Department of Fisheries and Environment, 1978).

[2] Sheaffer & Roland, Substantial Improvement, p. 3

(Scenario I), (2) regulating the 100-year floodplain in a manner similar to the current minimum requirements of the National Flood Insurance Program (Scenario II), and (3) forbidding new development and substantial improvements in the 100-year floodplain and "correcting" past land use decisions which interfere with the natural functions of the floodplain by removing unwarranted structures (Scenario III).

A further difference between Scenarios II and III is that Scenario II allows vertical adjustments of development (by elevation or flood proofing to the regulatory level) or a horizontal shift of development out of the 100-year floodplain. Scenario III on the other hand, permits only horizontal adjustment, preventing further development within the 100-year floodplain. This extends to both new construction and any proposed substantial improvements. Therefore, Scenario III may not be deemed to be a reasonably viable option, just as Scenario I (no regulations) is normally not. However, from a research perspective it is desirable to cover the extreme range of theoretical regulatory options.

To avoid obscuring the effects of a particular scenario, variations in regulations among local governments were not considered. This eliminates the ability of communities to compete with respect to the stringency of regulations. Each scenario was assumed to be applied uniformly throughout the nation. All regulations were assumed to be properly administered and enforced. The differences between the evaluated effects for the three regulatory scenarios for the case study communities are presented in Table 2. To facilitate comparisons, both amounts and percentages of change from 1975 to 1980 and 1990 are presented.

Economic Effects

When no regulations are applied (Scenario I), average annual flood losses increase sharply. It is projected that flood losses

Table 2: Case Study Summaries of Economic, Social, and Environmental Effects of Floodplain Regulations: 1975-1990

Characteristic	1975	1980			1990		
		Scenario I	Scenario II	Scenario III	Scenario I	Scenario II	Scenario III
Urban Flood Losses[a] **(Avg. Annual, in millions)**	$ 76.6	$ 98.6	$ 79.4	$ 76.4	$131.0	$ 84.6	$ 76.1
Change from 1975 (%)		+29	+4	b	+71	+10	-1
Housing Units	162,800	184,100	176,300	160,500	219,700	197,900	156,700
Change from 1975 (%)		+13	+8	-1	+35	+22	-4
Housing Units at Risk	87,400	98,400	85,700	85,800	116,500	83,300	83,600
Change from 1975 (%)		+13	-2	-2	+33	-5	-4
Population	480,500	537,200	513,100	470,200	619,300	562,900	453,700
Change from 1975 (%)		+12	+7	-2	+29	+17	-6
Population at Risk	265,500	301,100	261,000	261,100	354,000	247,100	247,900
Change from 1975 (%)		+13	-2	-2	+33	-7	-7
Developed Acres (loss of open space)	59,300	67,900	64,500	58,900	81,400	73,500	58,300
Change from 1975 (%)		+15	+9	-1	+37	+24	-2

a = flood losses expressed in 1975 dollars
b = less than one-half of one percent decline

under Scenario I would increase 29 percent over 1975 levels by 1980 and 71 percent by 1990. Approximately 50 percent of these increased average annual flood losses would be suffered by residences.

Moderate regulations (Scenario II), however, greatly limit the rate of growth in average annual flood losses. The losses increase by only 4 percent over 1975 levels by 1980 and only 10 percent by 1990.

The reduction in the rate of flood loss increases is associated with the reduction in exposure to damages from the 100-year flood. This reduction in exposure is a result of regulations and is achieved partly by horizontal shifts of development to locations outside the floodplain and partly by vertical shifts, i.e., elevating and flood proofing buildings. Damages do increase slowly, however, because buildings shifted vertically are still vulnerable to greater flood events. To the degree that moderate regulations permit development within the 100-year floodplain, there remains the potential for future losses from floods greater than the 100-year flood.

Regulations that prevent development (Scenario III) produce a small, but measurable, gradual decline in average annual flood losses over the long term because of the corrective elements which begin to reduce the number of existing floodplain structures. This decline reaches approximately one percent by 1990. Scenario II has no workable corrective elements and still allows flood proofed development. Thus, it shows a small increase in flood losses. These increases are significantly lower than those which would be experienced under Scenario I.

While regulation would divert development from the 100-year floodplain in selected study areas, such development can be accommodated within the economic region of such study areas. This is true even for those case study areas that had limitations on alternative sites for development. For example, Wheeling and Jersey Shore have steep topography and Orleans Parish has most of its remaining undeveloped land in the 100-year floodplain, yet they would also be able to accommodate projected development.

The effect of floodplain regulations on the tax base of the study areas was estimated to be small. Based upon data drawn from some case studies, it appears that elevation and flood proofing requirements increase residential property value by as much as 10 percent. This reflects a combination of increased investments and reduced flood losses. In Scenario II, the tax base would not be reduced by complying with flood proofing regulations and conceivably could be expanded to reflect the increased value of flood proofed structures. The tax base in a local coastal hazard area, however, could be reduced under Scenario III if development were dependent solely on exposure to the water.

Social Effects

Many social effects of floodplain regulations are directly related to the number of people and their property which are located within the 100-year floodplain. Thus, forecasts of housing and population at risk provide insights into potential social effects.

Regulations have profound effect on the number of housing units in the 100-year floodplain. With no regulations, Scenario I, the total number of housing units that would be located in the 100-year floodplain would increase from 162,800 in 1975 to 184,100 by 1980 and 219,700 by 1990. This represents a 13 percent increase by 1980 and a 35 percent increase by 1990. Moreover, the population residing in the 100-year floodplain would increase from 480,500 in 1975 to 537,200, or 12 percent, by 1980 and to 619,300, or 29 percent, by 1990.

With moderate regulations, Scenario II, the number of housing units and population residing in the 100-year floodplain would increase at a slow rate. Housing units would increase from 162,800 in 1975 to 176,300, or 8 percent, by 1980 and to 197,900, or 22 percent, by 1990. Population would increase from 480,500 in 1975 to 513,100 in 1980 and 562,900 in 1990, 7 and 17 percent increases, respectively. Thus, with moderate regulations, Scenario II, as compared with no regulations, Scenario I, by 1990 there would be 10 percent fewer housing units and 9 percent less population residing in the 100-year floodplain. Moreover, housing units and population at risk would decline by 1990 relative to their 1975 levels under Scenario II due to the removal of deteriorated units at risk and their replacement with new units not at risk. Similar declines would be achieved under Scenario III.

Relative to 1975, stringent regulations, Scenario III, would result in fewer housing units and less population residing in the 100-year floodplain. The number of housing units would decline from 162,800 in 1975 to 160,500, or 1 percent, by 1980 and to 156,700, or 4 percent, by 1990. Population in turn would decrease from 480,500 in 1975 to 470,200, or 2 percent, by 1980 and to 453,700, or 6 percent, by 1990. In contrast to no regulations, Scenario I, the number of housing units by 1990 under stringent regulations would be 29 percent fewer and the population would be 27 percent lower in the 100-year floodplain. Compared with moderate regulations, by 1990 there would be 21 percent fewer housing units and 19 percent less population in the 100-year floodplain under stringent regulations.

The effects on residential occupance at risk are even more profound with no regulations compared with either moderate or stringent floodplain regulations. The number of housing units and population at risk when no regulations, Scenario I, are applied would by 1990 be 39 and 44 percent higher, respectively, than residences and persons at risk under either moderate, Scenario II, or stringent, Scenario III, regulations.

New development that would have occurred within the 100-year floodplain would adjust in two ways. With Scenario II, some development would take place within the floodplain but would be elevated or flood proofed to the level of the 100-year flood. These adjustments, in essence, remove the development from the defined risk area. The remaining development would be shifted outside the floodplain. This horizontal shift may be in response to hazard awareness or may reflect, in part, a belief that the cost of flood proofing is not warranted. Under Scenario III all new development would be required to be located outside the hazard area.

Environmental Effects

Environmental effects of floodplain regulations can be related to acreage and their magnitude can be determined from the quantity of open space in floodplains. The development of the floodplain could diminish the inherent environmental values which are provided by open floodplains. Under Scenario I, there would be a continuing, unlimited conversion of floodplain open land to urban uses; Scenario II permits limited conversion. This diminishes the environmental benefits that are provided by the natural floodplain ecosystem. Scenario III would not allow any further development of the floodplain and would begin the slow process of removing existing development.

The number of floodplain acres that would be developed under Scenario I is 22,100 acres by 1990, or 37 percent more than the 59,300 acres developed as of 1975. With moderate regulations, 14,200 acres would be developed in the 100-year floodplain by 1990, or 24 percent more than 1975. This is 10 percent fewer developed acres than no regulations under Scenario I. Under stringent regulations, Scenario III, there would be 1,000 fewer developed acres by 1990 than in 1975, or a 2 percent reduction. This means there would be more floodplain open space in 1990 than existed in 1975.

Scenario III would not permit any additional conversion of open land to development, thereby preserving the environmental effects and even improving them through the removal of existing structures. Examples of these environmental effects include: the storage of flood water, the recharge of flood water to the groundwater reservoirs, the preservation or enhancement of channel cross sections, and the maintaining of floodplain ecosystems.

New floodplain development under Scenarios I and II can increase the discharged pollutants into waterways though in differing degrees. This results, in part, from the reduction in the purifying properties of the floodplain acreage and the increase in runoff having direct access to the waterways. These effects diminish the value of the 100-year floodplains as open space which provides wildlife and recreational benefits. Under Scenario III, the discharge of pollutants would not increase and the open space values of the floodplain would be preserved and even enhanced.

National Urban Perspective

The case studies can be regarded as a sample that is skewed toward large communities. This permits limited extrapolation of case study findings to those parts of the nation where development will take place and where the effects of floodplain regulations can be measured.

The national projections, presented in Table 3, are limited to the following characteristics: urban flood losses, housing,

Table 3: National Extrapolations of the Economic, Social, and Environmental Effects of Floodplain Regulations: 1975-1990.

Characteristic	1975	1980			1990		
		Scenario I	Scenario II	Scenario III	Scenario I	Scenario II	Scenario III
Urban Flood Losses[a] (Avg. Annual, in billions)	$1.215	$1.564	$1.260	$1.213	$2.079	$1.341	$1.208
Change from 1975 (%)		+29	+4	b	+71	+10	-1
Housing Units (millions)	7.4	8.3	8.0	7.5	9.9	8.9	7.0
Change from 1975 (%)		+13	+8	-1	+35	+22	-4
Housing Units at Risk (millions)	4.0	4.5	3.8	3.9	5.3	3.8	3.8
Change from 1975 (%)		+13	-2	-2	+33	-5	-4
Population (millions)	24.1	27.0	25.8	23.6	31.1	28.3	22.8
Change from 1975 (%)		+12	+7	-2	+29	+17	-6
Population at Risk (millions)	13.3	15.1	13.1	13.1	17.8	12.4	12.5
Change from 1975 (%)		+13	-2	-2	+33	-7	-6
Developed Acres (loss of open space, in millions)	4.3	5.0	4.7	4.3	6.0	5.4	4.3
Change from 1975 (%)		+15	+9	-1	+37	+24	-2

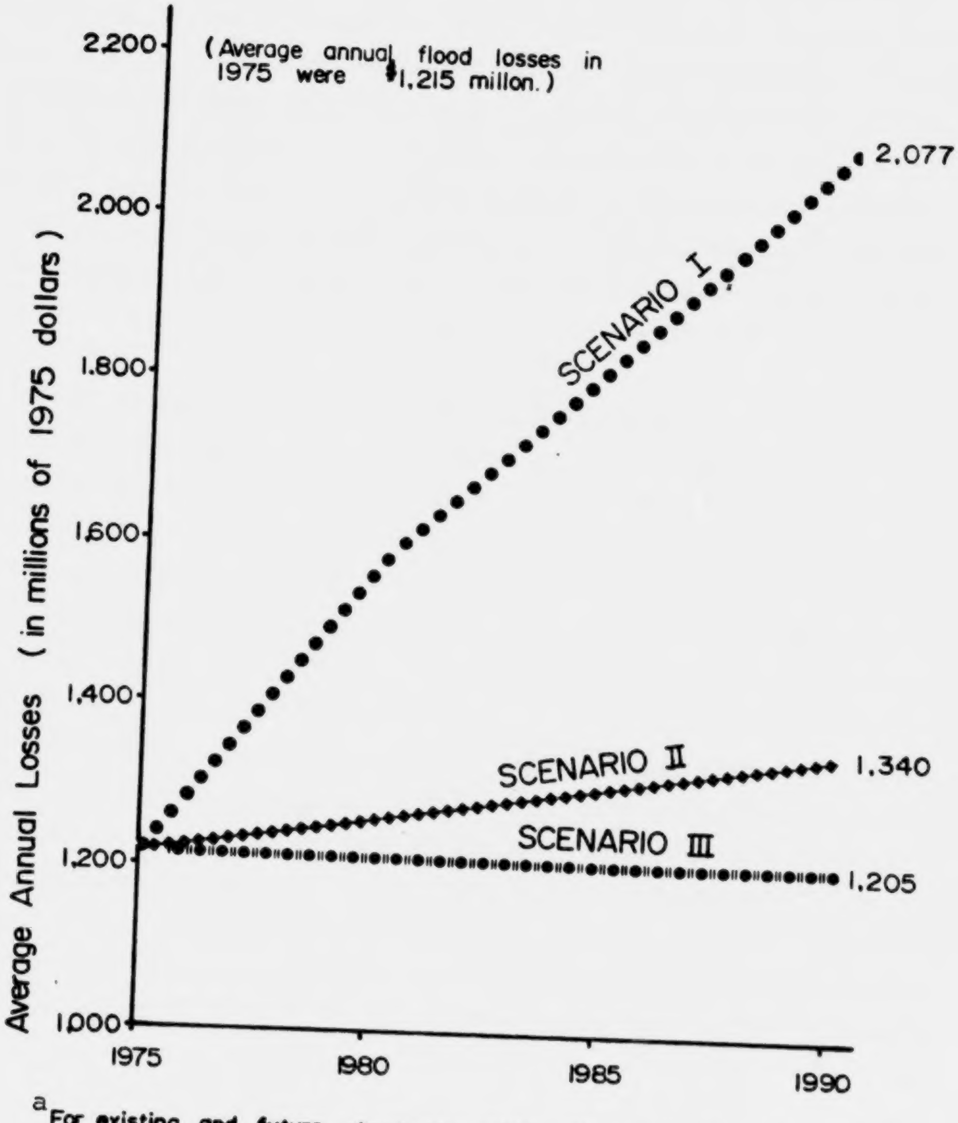
a = flood losses expressed in 1975 dollars
b = less than one-half of one percent decline

housing at risk, population, population at risk, and developed acreage. The national projections are derived from the application of the rates of change of the aggregate case study projections in each evaluated category to national estimates for each scenario by 1980 and 1990. Hence, the percent changes in Table 3 correspond to those shown in Table 2. This type of extrapolation allows one to estimate the magnitude of the effects of floodplain regulations nationally. Although the case study communities are not a random sample and are skewed toward large communities with flood problems, they appear to provide a useful forecast of national trends. The results closely parallel the Water Resource Council estimates of future flood losses.

With no regulations, it was found that urban flood losses, housing and population at risk would increase dramatically. Urbanization of the floodplain would consume a vast amount of open space. Moderate regulations (Scenario II) were found to suppress the rate of increase in urban flood losses and reduce housing and population at risk. Stringent regulations (Scenario III) were found to reduce urban flood losses as well as housing and population at risk even more. Stringent regulations would preserve and enlarge floodplain open space, whereas urbanization of the floodplain would continue at a reduced rate under moderate regulations. Property values would be minimally affected by moderate regulations while, to some extent, expected windfall profits would be cut by stringent regulations. In essence, moderate regulations produce an array of desirable economic and social effects. These effects are improved by stringent regulations which, in addition, produce environmental and recreational benefits.

Alternative trends in average annual flood losses are depicted in Figure 2. With no regulations, Scenario I, average annual urban flood losses would increase by $864 million, from

Figure 2: Alternative Trends in Average Annual Flood Losses for U.S. Urban Floodplains [a]



[a] For existing and future structures within the currently delineated flood hazard area.

$1.2 billion in 1975 to $2.1 billion by 1990. Under moderate regulations, Scenario II, average annual urban flood losses would increase from the $1.2 billion level in 1975 to $1.3 billion by 1990, an increase of $125 million. National compliance with minimum FIA type regulations (Scenario II) would bring about a reduction in average annual flood losses of $738 million compared with Scenario I . Under stringent regulations, Scenario III, average annual urban flood losses would decline from 1975 levels by $10 million by 1990, from $1.215 billion in 1975 to $1.205 billion. Thus by 1990, under Scenario III, there would be $871 million less in average annual urban flood losses compared with no regulations.

These conditions reflect, in part, the effects of floods greater than the 100-year flood. It is reported that floods greater than the 100-year flood have caused 61 percent of the losses experienced in the United States during the period from 1959 to 1974.[1] The distribution of flood losses from these unusual and disastrous events included both structures within and outside the 100-year floodplain. However, if uniform distribution of development is assumed for the entire floodplain, it appears that the losses would occur primarily within the 100-year floodplain.

The number of housing units at risk from the 100-year flood with no regulations, Scenario I, would increase by 1.3 million from 4.0 million in 1975 to 5.3 million by 1990. Population at risk with no regulations would increase by 4.5 million from 13.3 million in 1975 to 17.8 million by 1990. Thus, an additional 4.5 million persons and 1.3 million housing units would be subject to risk from the 100-year flood. Under both moderate and stringent regulations, the number of housing units and people at risk from the 100-year flood by 1990 would be reduced compared to the number at risk in 1975 by about 200,000 housing units and 900,000 people, respectively. Compared with Scenario I there would be about 1.6 million fewer housing units and 5.3 million fewer people at risk.

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[1] Sheaffer & Roland, Inc., Flood Hazard Mitigation Through Safe Land Use and Construction Practices (Washington, D.C.: Department of Housing and Urban Development, 1976) Table 9, p. 49.

The number of developed acres in the floodplain would increase with no regulations, Scenario I, from 4.3 million in 1975 to 6.0 million by 1990, an approximate increase of 1.7 million. This is the amount of open space land that would be converted to developed uses in the nation's urban floodplains by 1990. Because development would be allowed in the floodplain under the moderate regulations of Scenario II, albeit free from 100-year flood losses, the number of open space acres converted to developed uses would be 1.1 million by 1990. Under stringent regulations, Scenario III, there would be a recovery of 69,000 acres in open space in the 100-year floodplain by 1990 over the 1975 level. In comparison with Scenario I and II, this represents, respectively, 1.7 and 1.1 million fewer developed acres in the nation's 100-year floodplains.

Program Implications of Research

Since 1936, flood control and flood-related statutes enacted by the Congress have sought to reduce and alleviate damage caused by floods. The goals expressed by the Congress are epitomized by the National Flood Insurance Act of 1968, as amended, stating that the purposes of the Act are to:

> ...(1) encourage State and local government to make appropriate land use adjustments to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses, (and) (2) guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards.[1]

The research results show that Scenario II will greatly reduce the rate of increase of flood losses, but will not produce a decline in such losses. To achieve a decline in the present level of flood losses (hazard mitigation), a strong national effort would have to be made to change existing land use in the urban floodplains. Such corrective elements can be achieved along with other floodplain management measures through technical and financial assistance.

If the corrective elements of Scenario III and the provision of technical assistance are added to Scenario II, it is probable that the effects would closely approach those of Scenario III. Such a program would assist communities to achieve their comprehensive community development goals while at the same time allow them to reduce their flood losses. It would also reduce national flood losses, a goal envisioned in Federal flood-related legislation enacted since 1936.

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[1] National Flood Insurance Act, as Amended, sec 1302 (e), 82 Stat. 572 (1968).

CHAPTER II

SETTING FOR THE RESEARCH

An evaluation of the economic, social, and environmental effects of floodplain regulations is aided by an understanding of the basic approaches to floodplain management. These basic approaches are presented to demonstrate the range of options available and to help identify the potential role of floodplain regulations. The role of floodplain regulations will vary with the regional settings. This research is limited to evaluating the effects in urban areas. These are the areas where regulations generally are applied.

Basic Approaches to Floodplain Management

There are three basic approaches that individuals and communities can use in response to their flood hazard. The approaches are: (1) to do nothing; (2) to build flood control structures to mitigate flood losses; and (3) to manage the use of floodplains ("nonstructural" actions) to mitigate flood losses. Each of these approaches and combinations is involved to a degree in the current national floodplain management program which is a multiple means effort.

The "Do Nothing" Approach

The "do nothing" approach relies on market forces to effect an equilibrium between benefits of floodplain occupance and the flood losses that are experienced. In this case, losses sustained by floodplain occupants, whether private or public, are not mitigated by relief of any kind, by the construction of any flood control facilities, or by regulation of floodplain use.

Experience has shown that the acceptability of the "do nothing" approach in urban areas pales when heavy flood losses are actually experienced. Thus, the "do nothing" approach is more of a theoretical choice than a viable choice.

The Structural Approach

The structural approach to floodplain management is based on the premise that floodplain occupance is desirable, if not necessary. It, therefore, seeks to reduce (or "correct") the impact of a flood by structural works that are designed to control or modify the flood to reduce the risk to the floodplain occupants.

The structural approach to floodplain management was the one initially pursued on a national level. However, experience has led to a widespread recognition that sole reliance on structural solutions results in an escalation of average annual flood losses and corresponding demands for new structural solutions. It has become evident that it is possible to create flood problems faster than they can be solved by the construction of flood control structures alone.

To illustrate, a $10 billion investment in a nationwide network of structural flood control works between 1936 and 1977 (e.g., levees, channel improvements, multi-purpose reservoirs) has not reduced the magnitude of flood losses in the United States.[1] Annual flood losses for the nation between 1971 and 1974 averaged $1,857 million per year.[2] The Water Resources Council estimated average annual flood damages in 1975 at $3,616 million; of this amount, $1,215 were urban flood damages.[3]

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[1] Statement of the President accompanying Executive Order 11988, 24 May 1977.

[2] U. S. Weather Bureau, Atlas.

[3] Water Resources Council, Flood Damages.

Disaster relief payments to flood victims also increased and now average $235 million per year.[1]

The Nonstructural Approach

The nonstructural approach promotes land use and construction practices which result in an occupance pattern with decreased vulnerability to the flood hazard. By modifying the land use and/or flood proofing structures, a community reduces the risk associated with the 100-year flood hazard. Uses deemed undesirable for the floodplain are located in the nonhazard areas.

The Need for a Comprehensive Approach

To address the problem of increasing losses, safe land use and construction practices must be incorporated into a comprehensive floodplain management program along with structural flood control works. One element of such a program is floodplain regulations. When carefully analyzed, floodplain regulations are seen to include both preventive and corrective elements. The relationships of these elements are illustrated in Figure 3. In essence, floodplain regulations have the same thrusts as overall comprehensive floodplain management. The similarity can be seen by comparing Figure 4, a diagram of the comprehensive Tennessee Valley Authority program, with Figure 3.

Regulation of Existing Uses

The corrective aspects of floodplain regulations include removal of nonconforming uses through substantial improvement regulations and flood proofing existing structures. The effectiveness of substantial improvement regulations to remove

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[1] Federal Disaster Assistance Administration, based on 1971 through 1977 data.

Figure 3 : Corrective and Preventive Aspects of Floodplain Regulations

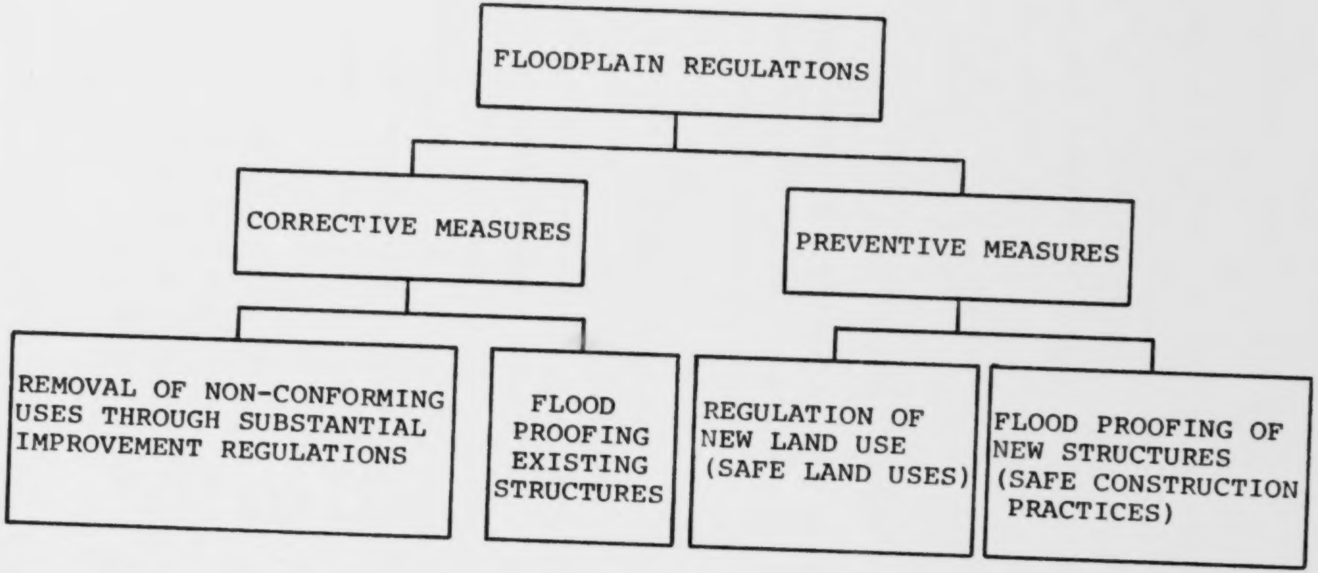
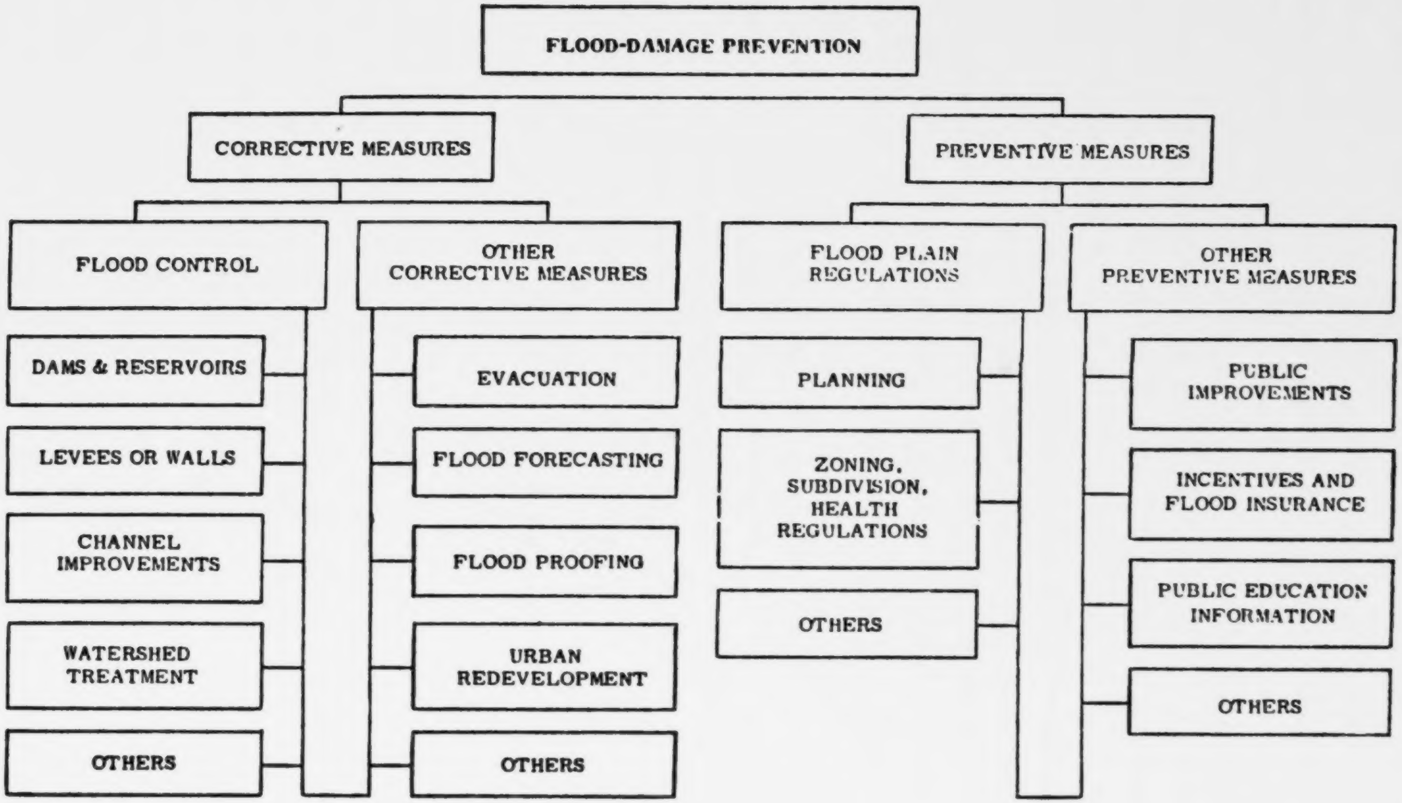

FLOODPLAIN REGULATIONS
CORRECTIVE MEASURES
PREVENTIVE MEASURES
REMOVAL OF NON-CONFORMING USES THROUGH SUBSTANTIAL IMPROVEMENT REGULATIONS
FLOOD PROOFING EXISTING STRUCTURES
REGULATION OF NEW LAND USE (SAFE LAND USES)
FLOOD PROOFING OF NEW STRUCTURES (SAFE CONSTRUCTION PRACTICES)

Figure 4 : Corrective and Preventive Measures of a Floodplain Management Program



Source: Tennessee Valley Authority (1962) nonconforming uses from the special flood hazard area generally is overestimated. To illustrate, a detailed analysis of this issue in related research found that, on an average annual basis, only 13,600 housing units located on the 100-year floodplain would be either damaged substantially by fires, floods or other natural disasters or would be candidates for substantial improvements.[1] The study also found that in planning and zoning agencies such regulations are not significant. The record is one of minimal enforcement due to political and financial constraints. However, even were enforcement 100 percent effective, only 15 percent of all existing residential units located within the special flood hazard area would be affected by substantial improvement regulations over a 50-year period.

The mitigation of average annual flood losses to existing buildings through the retrofitting of flood proofing measures is carried out on a limited basis in selected areas across the nation. A range of potential flood proofing measures is identified in several publications.[2] The decision to retrofit an existing building with flood proofing measures is prompted generally by economic considerations, e.g., the need to reduce flood losses.

In conjunction with its land use and building regulations, the National Flood Insurance Program (NFIP) makes available flood insurance to existing structures at subsidized rates. Structures that are in conformance with the regulations can secure insurance at actuarial rates. These rates are lower than the subsidized rates. Thus, flood proofing of both existing and new commercial buildings may be justified by the reductions in flood insurance premiums that would be realized. To illustrate subsidized rates of 40¢ per $100 could be reduced through flood proofing to as low as 1¢ per $100 based on actuarial rates when the structure is flood proofed to an elevation 1 foot above the 100-year flood elevation.

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[1] Sheaffer & Roland, Inc., Substantial Improvement, pp. 1-8.

[2] See Hydrologic Engineering Center, Institute for Water Resources, U.S. Army Corps of Engineers, Physical and Economic Feasibility of Nonstructural Floodplain Management Measures (Davis: March 1978); James F. McLaren, Ltd., Flood Reduction; and John R. Sheaffer, Flood Proofing: An Element in a Flood Damage Reduction Program (Chicago: University of Chicago, Center for Urban Studies, 1967).

Regulatory aspects of flood proofing measures are presented in a Corps of Engineers publication.[1] This publication is written in a format that is adaptable for use in local building codes.

Regulation of New Land Uses

Regulation of new land uses is a preventive measure. As noted above, there is a minimal potential to reduce national flood losses by eliminating nonconforming existing uses on a voluntary or *ad hoc* local basis. The greatest potential to reduce flood losses is a regulatory policy that emphasizes the prevention or limitation of increases in *future* floodplain occupance.

Flood proofing new structures (safe construction practices) is also a preventive measure. It is applicable to desired uses of a floodplain. The regulations regarding such flood proofing can be incorporated into zoning, subdivision, or building requirements.

An analysis of the feasibility of flood proofing a new small commercial structure showed it to be economically justified, although it increased the building costs from 6 to 16 percent.[1] Economic justification was evident when the annual benefits were compared with annual costs either in terms of reduced flood losses or reduced flood insurance premiums. The benefit/cost ratios calculated for flood proofing alternatives that were consistent with NFIP regulations ranged from 2.5 to 6.0 when the reduced flood insurance costs were compared to the cost of flood proofing and from 1.6 to 3.5 when the reduction in flood losses was compared to the costs of flood proofing.

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[1] Office of the Chief of Engineers, *Flood-Proofing Regulations* (Washington, D. C.: June 1972).

History and Evaluation of Floodplain Regulations

The initially dominant approach to floodplain management for urban areas was the construction of corrective flood control works.[2] It was believed that such structural efforts would reduce the nation's flood losses. Experience showed that flood losses continued to increase, albeit at a reduced rate, when the floodplain management program consisted primarily of flood control structures.[3] In 1953, James E. Goddard of the Tennessee Valley Authority recognized this and organized a Local Flood Relations Branch. A cooperative program was initiated with State and local governments to regulate land use and construction practices in local floodplains. In 1958, Francis C. Murphy evaluated the status of floodplain regulations in the United States.[4] Murphy concluded that an approach restricted to the imposition of Federal regulations would not succeed and would in fact be counterproductive. In his judgment, technical assistance provided by the Federal government, including the funding of local planning efforts, would engender the kind of local response necessary to secure their active participation.

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[1] Sheaffer & Roland, Inc., Feasibility, p. 2.

[2] Flood Control Act of 1936, 49 Stat. 1570, 22 June 1936.

[3] A Unified Program for Managing Flood Losses, House Document No. 465; 89th Congress, 2d session (1966).

[4] Francis C. Murphy, Regulating Development, pp. 163-4.

Congress demonstrated its appreciation of the need to manage floodplains by authorizing the Corps to conduct floodplain information studies.[1] Floodplain information reports prepared were to engender public awareness of the flood hazards and to alert the occupants to the availability of a range of potential floodplain management measures.

Another major departure from the historical approach that had so dominated floodplain management was introduced in 1968. Passage of the National Flood Insurance Act of 1968 (PL 90-448) created a flood insurance program that was linked to floodplain regulations. This created a national program to which State and local floodplain regulations could be related.

By January 1972, 972 communities out of some 20,000 identified flood-prone communities had adopted some type of floodplain regulation and were eligible for flood insurance.[2] However, in 1972, catastrophic flooding resulted in annual damages of $4,889 million, and disaster relief payments of $591 million ($760 million in 1975 prices).[3] These spiraling losses helped to stimulate enactment of the Flood Disaster Protection Act of 1973.[4] Under this new legislation, communities upon receipt of floodplain information,adopted regulations. By December 31, 1978, 16,192 communities had agreed to enact some floodplain regulations.[1]

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[1] Flood Control Act, sec. 206, 74 Stat. 500 (14 July 1960).

[2] Federal Insurance Administration.

[3] U. S. Weather Bureau, Atlas.

[4] PL 93-234 (1973).

Other Federal legislation began to reverse the bias toward structural approaches. Section 73 of the Water Resources Development Act of 1974 (PL 93-251 of 1974) requires all Federal agencies to give equal consideration to nonstructural approaches in any request for flood control expenditure.[2] It also permits an 80 percent Federal investment in nonstructural measures.[3]

Other Federal authorities, such as Corps of Engineers regulation ER-1120-2-117 and Principles and Standards for Planning Water and Related Land Resources, demand equal and unprejudiced evaluation of nonstructural alternatives.[4] The latter requires evaluation of the effect of Federal actions on national economic efficiency and environmental quality. Under the broad authority of the Department of Housing and Urban Development (HUD), comprehensive planning (Section 701 of the Housing Act of 1954), urban renewal (now defunct), community development (Section 101 of the Housing and Community Development Act of 1974), and disaster assistance programs administered by FDAA have been structured to incorporate comprehensive floodplain management measures in their activities. In some of these programs, emphasis is focused on the enactment of safe land use and construction regulations.[5] Executive Orders No. 11988 and 11290 discourage and set conditions and requirements for evaluating potential development in floodplains and wetlands areas.[1] The President, as part of his National Water Policy Revision, issued a memorandum to the Secretaries of the Army, Commerce, HUD, and Interior on July 12, 1978 that called for emphasis on nonstructural flood protection methods. He directed them to utilize existing programs to encourage the use of nonstructural floodplain management practices.

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[1] Federal Insurance Administration.

[2] Water Resources Development Act, 88 Stat. 12, 14 (7 March 1974).

[3] Small Watershed Program authorized by the Watershed Protection and Flood Prevention Act of 1954. PL 83-566 (1954).

[4] Corps, "Investigation" and 38 FR 24778 et seq. (10 September 1973), respectively.

[5] Disaster Relief Act of 1974, PL 93-288, Section 406.

Evolution of State and Local Floodplain Regulations

In 1958, a national assessment of floodplain regulations showed that only 7 State and 35 local governments had acted to regulate their floodplains.[2] Such ordinances as existed were usually ineffectual or irrelevant. Ninety-eight percent of the land zoned as floodplain was completely undeveloped; the attempt to regulate development in areas actually experiencing development was found to be half-hearted. Areas that had been zoned as flood hazard areas were found to be consistently upzoned for more intensive development following construction of levees. Subdivision regulations were generally referenced to 15 to 35 year design floods. Building codes did not deal with the flood hazard. Only spotty success was recorded in urban renewal and acquisition of floodplain land, and only then through the infusion of Federal monies. This poor record was largely attributable to the fact that local regulations were not integrated into a comprehensive program of flood damage reduction applying appropriate techniques to specific problems.

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[1] "Floodplain Management" and "Protection of Wetlands" (24 May 1977), respectively.

[2] Murphy, Regulating Development.

A Water Resources Council survey was conducted in 1970-71 to establish the extent to which the various states had progressed in enacting enabling floodplain regulation legislation.[1] Specific reference to flood hazards appeared in the statutes of 27 states with respect to zoning, 9 states with respect to subdivisions, and 15 states with respect to other aspects of the police power. This evaluation assessed the magnitude of local regulatory efforts. Using September 1969 as the survey time, it found that the zoning of riverine flood hazard areas was in effect in 40 states, 183 municipalities, and 71 counties. Subdivision regulations were identified in 167 municipalities and 27 counties. It was observed that specific enabling legislation with reference to flood hazards was not necessary for communities to act. Where needs were perceived, floodplain regulations were implemented under the "general welfare" clauses of the statutes.

A study of 180 municipalities and 77 counties as a sample was undertaken in 1972 to estimate the extent of floodplain regulations.[2] Of the municipalities responding, 69 percent reported they had enacted floodplain regulations. With respect to the counties, 78 percent of those responding reported regulations. The majority of these regulations, 59 percent, had been enacted after 1960.

By 1974, State enabling legislation was broadened considerably. Specific authorization to regulate against flood hazards was present in 46 states with respect to zoning, 42 states with respect to subdivisions, and 12 states with respect to building codes.[1] Thus, municipalities and counties have been delegated broad powers to regulate floodplains. The exercise of these powers by communities is both widespread and varied.

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[1] Jon A. Kusler and Douglas A. Yanggen, _et al._, _Regulation of Flood Hazard Areas to Reduce Flood Losses_, vols. 1 and 2 (Washington: Water Resources Council, 1970-71).

[2] Jon A. Kusler and T. M. Lee, "Regulations for Floodplains," Planning Advisory Service, Report No. 277 (Chicago: American Society of Planning Officials, 1972).

A 1975 survey of 100 local governments reputed to have effective floodplain regulation programs (70 municipalities, 29 counties, and 1 council of governments) showed that 37 percent prohibited development from at least part of the floodplain, and that 16 percent forbade residential use of at least part of the floodplain.[2] The availability of better information about the flood hazard made possible an enactment of multiple zone ordinances in 50 percent of the sample communities. In multiple zone communities, floodways were distinguished from flood fringes and in 7 communities the floodplain outside the 100-year boundary was regulated.[3]

Refinement of regulatory approaches led to widespread regulation of activities other than construction of private buildings. Landfills were regulated in 65 percent of the sample, storage of dangerous materials is regulated in 67 percent of the sample, and the siting of various public facilities was controlled in as many as 47 percent of the sample communities.[4] This study clearly showed that precedents for floodplain regulation do exist, and in fact they are virtually universal. The wide variety of regulations documented reflect the broad range of actions that are possible within the law to deal with specific needs.

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[1] Kusler and Associates, Statutory Land Use Control Enabling Authority in the Fifty States (Washington: Department of Housing and Urban Development, 1975).

[2] Sheaffer & Roland, Inc., Mitigation, Tables 19 and 21.

[3] Ibid., p. 109.

[4] Ibid., pp. 116-121.

The regulation of floodplain land uses and construction practices is becoming widespread. As of December 31, 1978, there were 2,994 communities participating in the Regular Program of the National Flood Insurance Program. In addition, 13,198 communities were participating in the NFIP Emergency Program.

Floodplain regulations are most effectively administered as part of an overall program for community management of land use and construction. Therefore, such regulations can be best implemented at the local level. The particular set of regulations adopted by a community reflects its unique perception of an equilibrium between special interests and the general welfare.

Need for the Research

Rapid expansion of floodplain regulatory activity has led to varied speculation concerning economic, social, and environmental effects of such regulation. Widespread community participation in the NFIP suggests that floodplain regulations address perceived needs. On the other hand, some communities have challenged the desirability of floodplain regulation. These communities have contended that the local costs of complying with floodplain regulations exceed the flood losses prevented. In addition, such regulations are alleged to produce adverse economic effects at the local level, e.g., reduced property values, loss of potential economic growth, and increased costs of construction to comply with standards. With respect to individuals, there are alleged losses in anticipated home equity, stifling of private initiative, shift of economic burdens onto lower income groups and diminished regard for government.

Vigorous objections by some interests against floodplain regulations suggest there may be some adverse effects. To assess the validity of the premise that community floodplain regulations produce net economic, social, and environmental benefits, empirical data on the effects of floodplain regulations were needed.

This research effort has gathered such empirical data. The study evaluates public and private benefits and costs of floodplain regulations over the short (1980) and intermediate (1990) term, at both the local and national level. An assessment of the economic, social, and environmental effects of floodplain regulation was derived from the empirical evidence gathered by this effort.

Chapter III generally describes the research approach which is referenced in Appendix B. The body of knowledge regarding the effects of land use regulation in general and floodplain regulation in particular is reviewed. A list of potential economic, social, and environmental effects gleaned from Congressional hearings, expert opinions, judicial decisions, and literature pertaining to floodplain management is presented. A screening of these potential effects eliminated some from further analysis. Case study areas were selected to test the remaining effects. Projection procedures to forecast future development under different regulatory scenarios are described. Finally, a method for aggregating and synthesizing the findings is explained.

Chapter IV presents the case study findings. First, the current occupance characteristics--housing, population, and land use--are presented for the 100-year floodplain and nonhazard area portions of the study areas. Economic and social characteristics of the population along with housing characteristics and environmental characteristics are analyzed. Finally, flood loss estimates are made for the various scenarios and an assessment of the economic effects of existing regulations is presented.

Chapter V provides an assessment of the effects of floodplain regulations. This is done for the three scenarios for the years 1980 and 1990. Economic, social, and environmental effects are evaluated by comparing the various scenarios and evaluating the differences between them. A national urban perspective is then formulated and findings presented.

CHAPTER III

THE RESEARCH APPROACH

This investigation was undertaken to identify and measure the economic, social and environmental effects of floodplain regulations. The evaluation of the effects is based chiefly on empirical data collected from a number of selected case study areas. A first step in the investigation was to identify potential effects. These potential effects were gleaned from the floodplain management and land use regulation literature. In addition, congressional hearing reports relating floodplain regulations were evaluated to identify effects.

The effects gleaned from the literature were augmented and corroborated by eliciting viewpoints from persons with recognized expertise in floodplain management. An assessment of the judicial recognition of the effects of floodplain regulations was undertaken. This was done by analyzing selected court decisions involving floodplain issues.

The combined results obtained from these four sources--congressional hearings, expert opinion, court decisions, and literature--identified the range of potential effects considered in this study. These effects were synthesized and organized under the general headings of economic, social, and environmental effects. It is significant to note that although these three classifications have significance in the floodplain management field, effects of regulations were not perceived within this framework. A screening of the potential effects was undertaken. Figure 1 (see page 4) presents the screening process used to arrive at the potential effects that could be considered in the case study areas.

The primary effects of regulations occur in the future. There are two basic ways to evaluate these effects. One is an historical approach which assesses changes over time which can be related directly to floodplain regulations. The historical approach was rejected because of the relative short period of time that regulations have been in force and the difficulty of assessing how effective the regulations were administered. The other approach is to project future conditions under different floodplain regulatory scenarios and evaluate differences. This approach was selected for the research. The base year for these projections was 1975, and the target years for evaluation were 1980 and 1990.

The conditions projected assumed that the regulations were imposed only in the 100-year floodplain. In the report, the use of the term floodplain or hazard area refers to the regulated area. While the natural or topographic floodplain extends beyond this boundary, this definition will be used for the sake of simplicity. Where other parts of the floodplain are treated, special reference will be made.

The effects of floodplain regulations were evaluated in a straightforward manner. To illustrate, one effect of a flood event is losses to structures and contents located on the floodplains. If floodplain regulations reduce the number of structures on the floodplain there is a related reduction in flood loss potential. This reduction in the flood loss potential is taken to be an effect of floodplain regulations. In evaluating effects, consideration was given to the total community and the economic region in which the floodplain was located when deemed necessary.

Floodplain regulations are intended to affect future land uses and development patterns. Thus, it is necessary to forecast future floodplain occupance under different regulatory scenarios to evaluate the effects. A projection of future floodplain occupance with no regulations was compared with projections of occupance under two degrees of floodplain regulations. One set of regulations evaluated in this manner was analagous to the minimum requirements of the National Flood Insurance Program as currently administered by the Federal Insurance Administration.[1] The other set of regulations is more stringent. It represents a program that will prohibit all new development and substantial improvements in the hazard area and gradually corrects existing land use problems in the floodplain. For convenience, these three sets of conditions are referred to as Scenario I (no regulations), Scenario II (moderate regulations), and Scenario III (stringent regulations). Since the primary intent of the study is to examine the economic, social and environmental effects of floodplain regulation, every effort was made to hold other conditions constant in all three scenarios. In addition, it was assumed that the floodplain regulations would be properly administered. This assumption was made to factor out of the research the effects of amendments and variances generally associated with the administration of land use regulations. This was done to preserve the differences between scenarios.

Projections of future conditions in the case study areas were based on available forecasts of population distributions and/or land uses. When field observations suggested that the available forecasts were not realistic, the forecasts were adjusted to be made compatible with either past trends or current development patterns. In a few cases, the analysis of the effects of regulations was influenced by conditions that have the potential to alter significantly the existing occupance and physical expanse of the hazard area. In so doing they have the potential to overshadow and alter the economic, social and environmental effects of floodplain regulations. These conditions include:

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[1] National Flood Insurance Program Rules and Regulations, Federal Register, Part II (26 October 1976), 41 F.R. 46962-46992.

1) the effects of a major proposed flood control structure;
2) the effects of a planned program of relocation and floodplain acquisition; or
3) the effects of a flood event greater than the 100-year flood (sometimes referred to as a catastrophic flood).

When such conditions were identified in the field investigations, an effort was made to account for their effects. The forecasts of population were then coverted into housing units and commercial and industrial activities. These uses were distributed within the case study areas based on land conditions and floodplain regulation scenarios. By combining this information with flooding characteristics, the effects of regulations can be estimated.

Identification of Potential Effects

An extensive search of Congressional hearings, expert opinion, judicial recognition of floodplain regulations, and literature pertaining to floodplain management was conducted to identify potential economic, social, and environmental effects of floodplain regulations. Summaries of the searches follow. Potential effects as gleaned from these sources are presented in Table 4.

Congressional Hearings

The effects of floodplain regulations reported here were expressed by those who testified in the Congressional hearings. They are similar to those identified in the literature survey

Table 4: Classification of Identified Effects

IDENTIFIED EFFECTS	SOURCES				
	LITERATURE	EXPERT OPINION	JUDICIAL RECOGNITION	HEARINGS	LEGISLATIVE OBJECTIVES
Protect property from damage/reduce damages	●	●	●		●
Protect against employment and income losses from disruption		●			
Protect against economic disruption in the production of goods and provision of services	●				
Will not protect property from catastrophic flood losses		●			
Protect public infrastructure in total system from disruption (sewer, water, gas, roads)			●		
Reduce property value, anticipated profits	●		●	●	
Reduce property value, loss in equity				●	
Inhibit transfer of real property/reduce marketability				●	
Reduce assessments and property taxes for occupants				●	
Maintain/preserve intrinsic economic value of property			●		
Divert/deter development from community				●	
Loss of jobs/industry				●	
Loss of tax base				●	
Development contained in community		●	●		
Protection of tax base			●		
Increase cost of construction			●	●	
Increase local government costs for administration				●	
Cost for relocating urban infrastructure		●			
Reduce need for structural flood control expenditures	●		●		
Reduce disaster aid expenditures (evacuation, relief, rehabilitation, and reconstruction)	●		●		●
Shift burden from general public to occupants of hazard area		●	●		●
Burden falls disproportionately on the disadvantaged (who are disproportionate occupants of hazard area)		●		●	
Discriminates against small communities (which cannot afford flood control works)				●	
Removes segment of population from housing market		●		●	
Divert development from hazard area		●			
Protect lives			●		●
Disincentive to rehabilitation/deterioration of housing, neighborhoods				●	
Protect against disruption of public services (e.g., assessment,etc.)	●				
Maintain/preserve recreation value of open space		●	●		
Change land use pattern		●			
Divert development to edge of hazard area		●			
Maintain/preserve open space	●	●			
Preserve groundwater recharge potential		●	●		
Preserve storage capacity/stormwater detention ability			●		
Preserve water quality			●		
Preserve air quality			●		
Preserve natural wildlife areas		●	●		
Preserve ecosystem quality (marshes, fisheries			●		
Avoid rising flood stages			●		
Reduce drainage problems				●	
Reduce downstream flooding				●	
Not preserve full storage capacity (because development outside hazard area is unregulated)				●	
Not avoid runoff problems				●	

CLASSIFIED EFFECTS WITH SUBDIVISIONS

ECONOMIC

- Flood Damages
  - Protect propert from damage/reduce damages
    - residential
    - business (commercial/industrial)
    - non-profit private property
    - public facilities
      - -buildings
      - -roads, bridges
      - -utilities
      - -sewers
      - -recreation
  - Will not protect property from catastrophic flood damages
- Disruption Losses
  - Protect against employment and income losses
  - Protect against disruption in the production of goods
  - Protect against disruption in the provision of commercial services
- Reduce Property Value/Marketability
  - Reduce anticipated profits
  - Loss in property equity
  - Inhibit transfer of real property/reduce marketability
  - Reduce assessments and property taxes for occupants of hazard area
- Maintain/preserve intrinsic economic value of property
- Economic Effects on the Community
  - Divert/deter development from community
  - Loss of jobs/industry
  - Loss of tax base
  - Not divert development from community--will contain development in community
  - Protection of tax base
- Cost of Compliance
  - Increase cost of construction
  - Increase cost of local government administration
- Cost for relocating urban infrastructure
- Reduce need for structural flood control expenditures
- Reduce disaster aid expenditures for
  - Evacuation
  - Relief

SOCIAL

- Shift Burden
  - Shift burden from general public to occupants of hazard area
  - Reduce disaster aid for rehabilitation and reconstruction
- Effects are Inequitable
  - Burden falls disproportionately on the disadvantaged (who are disproportionate occupants of the hazard area)
  - Discriminates against small communities (which cannot afford flood control works)
  - Removes segment of population from housing market
- Divert development from hazard area
- Protect lives
- Disincentive to rehabilitation/deterioration of housing, neighborhoods
- Protect public infrastructure in total system from disruption
- Protect against disruption of public services (e.g., assessment, etc.)
- Maintain/preserve recreation value of open space

ENVIRONMENTAL

- Land Use Changes
  - Change land use pattern
  - Divert development to edge of hazard area
  - Maintain/preserve open space
- Maintain/Preserve Environmental Value of Open Space
  - Groundwater recharge
  - Storage capacity/stormwater detention
  - Water quality
  - Air quality
  - Natural wildlife areas, fisheries
  - Ecosystem quality)plant and animal life)
    - -wetlands
    - -marshes
    - -estuaries
    - -coastlines
    - -wild rivers
- Hydrology/Flooding
  - Avoid rising flood stages
  - Reduce drainage problems
  - Reduce downstream flooding
  - Not increase storage capacity profoundly
  - Not reduce runoff problems profoundly (due to unregulated urbanization)

presented later. The magnitude of the effects in the hearings was presented in a more dramatic manner.

Testimony was presented that suggested that it was not possible to correct the unwise development that already exists in floodplains. The Mayor of Cape Girardeau, Missouri contended that the intent of the substantial improvement clause, a corrective element of floodplain regulations, was easily evaded.[1]

Economic effects were perceived by private property owners, financial institutions, developers, and local government officials who testified. It was claimed that there will be a reduction in property value when floodplain regulations prohibit certain development in floodways.[2] Others stated that property located in identified floodways is marketable. This condition was perceived to reduce anticipated profits, and to reduce real estate tax assessments.[3]

Financial institutions perceived numerous adverse impacts from floodplain regulations. Some contended that restrictions governing substantial improvement of houses could render existing homes unmarketable and could act as a disincentive to private investment in neighborhood rehabilitation.[1] In a similar vein, it was suggested that regulations would constitute a disincentive to maintain property value and could have a deleterious effect on the nation's housing stock in older communities.[2] Testimony was presented suggesting that the cost of elevating a house would be inflationary, have an adverse impact on housing succession, and could prevent lower income groups from purchasing existing homes, since "trading up" could be more restrained.[3]

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[1] Howard C. Tooke, Mayor of Cape Girardeau, MO, cited in Hearings before the Subcommittee on Housing and Community Development of the House Banking, Currency, and Housing Committee on H.R. 1677, H.R. 2459, and H.R. 3203, 94th Congress, 1st. sess. (1975), at p. 595-597.

[2] Joe A. Hubenak, Representative from Texas, cited in Public Hearings on Amendments to Floodplain Management Regulations, U. S. Department of Housing and Urban Development, Federal Insurance Administration (New Orleans, LA: 1975), at p. 18; John P. Gale, Jr., Brazoria County, TX Commissioners, cited in Amendment Hearings, at p. 53; and Harley W. Snyder, on behalf of National Association of Realtors, cited in House Hearings, at p. 783.

[3] D. Gerald Bing, General Engineering Contractor, cited in House Hearings, at p. 924.

Several testifiers speculated that increased construction costs could result from floodplain regulations. Estimates of the speculated costs varied from region to region. In Savannah, Georgia, estimates presented ranged from $4,000 to $15,000 per lot to elevate a home 3 to 8 feet.[4] On the other hand, estimates of $600 to $1,000 for increased site development costs for 6,000 square feet lots in Hampton, Virginia were presented.[5] The range of speculation was broadened by an estimate of $35,000 to elevate and flood proof a small fast-food restaurant in Cape Girardeau, Missouri.[6]

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[1] Robert M. Shofstahl, on behalf of the U. S. League of Savings Associations, cited in House Hearings, p. 780.

[2] Ibid.

[3] Harrison W. Fox, National League of Insured Savings Associations, cited in Hearings before the Subcommittee on Housing and Urban Affairs of the Senate Committee on Banking, Housing, and Urban Affairs, on S. 269, S. 390, S. 1495, S. 1840, and S. 1899, 93rd Congress, 1st sess. (June 1973), at p. 211.

[4] John Rousakis, Mayor of Savannah, GA, cited in Hearings before the Subcommittee on Housing and Urban Affairs of the Senate Committee on Banking, Housing, and Urban Affairs on S. 1495 and H.R. 8449, 93rd Congress, 1st sess. (October 1973), at p. 50.

[5] Tom Schreck cited in House Hearings, at p. 240.

[6] Thomas Halsouser, Engineer, Cape Girardeau, (MO) cited in House Hearings, at pp. 604-5.

Information presented by the Federal Insurance Administration suggested that flood proofing against sheet flow adds 1 to 2 percent to the cost of a building, and that flood proofing against other floods adds 5 to 10 percent.[1] The National Association of Realtors testified that the increase in construction costs for flood proofing would be insignificant.[2] A spokesman for the U. S. League of Savings Associations from New Orleans juxtaposed the high annual costs of flood insurance for structures at low elevations against the additional costs of elevating structures coupled with reduced flood insurance premiums; he concluded that the costs of elevating were paid for in a relatively short time by reduced flood insurance costs.[3]

Local government officials alleged that they could incur property tax revenue losses if assessments of property values were reduced because of floodplain regulations.[4] They also perceived a potential for the loss of new industry because of the need to adhere to floodplain regulations.[5] The anticipated cost to administer and implement floodplain regulations was suggested as a potential problem.[6] In areas where economic redevelopment is being pursued such as in flood-prone Appalachia, it was suggested that floodplain regulations could hinder redevelopment and perpetuate economic difficulties.[1]

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[1] J. Robert Hunter, Acting Federal Insurance Administrator, cited in House Hearings, at p. 98.

[2] Snyder, House Hearings, at p. 783.

[3] Shofstahl, House Hearings, at p. 780.

[4] Bill Frizzell, Mayor of Lake Jackson, TX, at p. 90, L. H. Jones, Brozosport, TX Chamber of Commerce, at p. 58, and B. H. Howard, Mayor of Richmond, TX, at p. 84, cited in Amendment Hearings; John P. Sammon, on behalf of the National Association of Realtors, at p. 241 and Nancy S. Phillipi, Illinois Department of Local Government Affairs, at p. 317, cited in June Senate Hearings; Rousakis, October Senate Hearings, at p. 50; and Terry L. Flowers, on behalf of the California Mortgage Bankers Association, cited in House Hearings, at p. 72.

[5] C. W. Reynolds, Mayor of Oyster Creek, TX, cited in Amendment Hearings, at p. 121.

[6] Monica Florian, cited in House Hearings, at p. 35.

It should be noted that the economic allegations made against floodplain regulations were not documented with empirical data. Nevertheless, the allegations resulted from genuinely perceived economic effects. In addition, the descriptions of potential effects did not take into account cost savings resulting from reduced flood insurance rates, reduced average annual flood damages, and other measurable benefits from floodplain regulations.

The most widely criticized aspect of the cost of floodplain regulations is that the effects fall primarily on the low income, elderly, minority, and young family segments of the population.[2] The cost of elevating new homes (varying from $699 to $1,500 per dwelling) was assumed to dissuade part of the population from entering the housing market, thus denying that group access to decent housing and the accumulation of wealth through the appreciation of real property.[3] In the same vein, several observers feared the further deterioration of central city neighborhoods because substantial improvements would render the entire structure vulnerable to actuarial rates.[4] Thus, the feeling was voiced that the burden of the program falls most inexorably on those with the least housing opportunity and the greatest need.

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[1] Leonard A. Shabman, ibid., p. 913.

[2] Fox, at p. 211, Richard P. Guidry, Representative from Louisiana at p. 328, and Luke A. Petrovich, Plaquemines Parish Commission Council, at p. 340, cited in June Senate Hearings; and Shofstahl, at p. 780, and Gene Judd, Associate Director, California Association of Realtors, at p. 156, and Hannaford, at p. 3, House Hearings.

[3] Jones, at p. 58, and Frizzell at p. 90, cited in Amendment Hearings; and Schreck, House Hearings, p. 248.

[4] Shofstahl, House Hearings, p. 780.

A perceived economic effect of floodplain regulations was the allegation that they take property value without due compensation. Thus, regulations were reported to be confiscatory, i.e., tantamount to the condemnation of land. The assumed impediments to sale and the assumed diminution of property value were viewed together as a taking without due compensation.

A surmised effect was that floodplain regulations discriminate against small municipalities, which cannot afford flood control works. Thus, they must accept a broad flood hazard area delineation, and are compelled to adopt regulations simply to avoid the sanction imposed as a result of nonparticipation.[1]

Discussion of potential environmental effects of floodplain regulations was limited. Environmental interests applauded floodplain regulations.

Testimony in the Congressional hearings is briefly summarized by the following items expressing generally the perceived effects of floodplain regulations.

1) loss of floodplain property value;
2) loss of real estate tax base and revenue to the community;
3) increased costs of construction in the floodplain, interpreted as increased building costs;
4) loss of property equity through implementation of the "substantial improvement" regulations;
5) floodplain regulations are not economically feasible; and their benefits do not exceed costs; and
6) the cost of floodplain regulations is borne by the poor, the elderly, minority groups, and young families, implying a discriminatory element in the regulations.

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[1] Shofstahl, House Hearings, at p. 780.

Expert Opinion

A number of nationally recognized floodplain managers and authorities and other interest groups involved in floodplain issues were contacted to elicit their viewpoints regarding the economic, social, and environmental effects of floodplain regulations. The individuals from whom opinions were elicited (see Table 5) represent a range of expertise that includes specific community knowledge and a broad national overview of flood problems and floodplain management issues. Their varied opinions, therefore, not only reflect differences in perception but at times acknowledge a range of experiences in different communities. (One authority, for example, predicted that the effects of regulations would differ through time.)

Several individuals indicated that there may be an impact on land use and development patterns. It was noted that development of floodways is being reduced and that a policy of acquiring open land is being strengthened. It was also hypothesized that development diverted from the hazard area would concentrate at the edges of the 100-year floodplain. At least one authority stressed that the catastrophic potential of flooding could be increased by a concentration of development at the edge of the 100-year floodplain.

The majority of the expected effects were defined in socioeconomic terms, as monetary costs that would shift the burden of cost or the pattern of home ownership. For example, some of the people interviewed believed that regulations (especially for flood proofing) and insurance requirements would impose extra costs that would force a considerable proportion of homeowners out of a particular market. Others expressed the views that floodplains are often inhabited by a disproportionate share of lower income groups, many of whom are not property

Table 5: Selected Contacts for Expert Opinion Interviews

Contacts	Affiliation
Authorities	
Charles R. Ford	Department of the Army
Robert M. Gidez	Jack Faucett & Associates
James E. Goddard	Floodplain Management Consultant
Frank Gregg	New England River Basins Commission
George Griebenow	Upper Mississippi Basin Commission
L. Douglas James	Utah State University
D. Earle Jones	Department of Housing & Urban Development, Washington, D. C.
Howard Kunreuther	University of Pennsylvania
Glen R. Wall	Tennessee Valley Authority
Gilbert F. White	University of Colorado
State Officials	
Jack Pardee	California
French Wetmore	Illinois
James M. Wright	Minnesota
Dirk Hoffman	New Jersey
John Carling	Pennsylvania
Tom Muellner	Wisconsin
Professional Interest Groups	
Environmental Defense Fund	
League of Women Voters of the U.S.	
National Association of Homebuilders	
National Association of Realtors	
National Wildlife Federation	
Sierra Club	
Disaster Relief Organizations	
Dan Marvin	Small Business Administration
Evelyn Sherry	Small Business Administration
Robert Blair	Federal Disaster Assistance Administration
Chesney Moran	Federal Disaster Assistance Administration
Ray Popkin	Red Cross, Disaster Services
C. Nelson Hastetter	Mennonite Church

owners. Therefore, it was expected that the burden of compliance would fall disproportionately on a group which cannot afford the marginal cost of flood protection structures. The reverse implication of this shift of burden was also hypothesized: increased awareness of the nature of flood disasters engendered by regulations and insurance has made the general public less inclined to repeatedly indemnify inhabitants of hazard areas. At least one authority, however, felt that floodplain regulations would not affect the distribution of the burden of flood losses. No agreement was evident as to whether or not changes in development patterns would necessitate increased cost for changes in urban infrastructure.

From an environmental perspective, regulations were deemed most effective in the preservation of currently undeveloped floodplains. Benefits associated with the preservation of these open spaces were thought to include recreation, groundwater recharge, and preservation of natural wildlife areas.

Insufficient empirical evidence was available for authorities to evaluate definitively the potential effects of floodplain regulations on the need for disaster relief. No authority could empirically connect floodplain regulations with changes in disaster expenditure levels although there was speculation that such a relationship exists.

The results of this effort to survey floodplain managers and authorities and other interest groups can be summarized. The effects perceived include:

1) changes in land use and development patterns on the 100-year floodplain and adjacent area;
2) increased housing costs which could force a considerable proportion of homeowners out of particular markets;

3) preservation of currently undeveloped floodplains which provide recreation, groundwater recharge, and natural wildlife benefits; and

4) reduced demand for disaster relief.

The identified effects from these expert opinions both overlapped and supplemented the effects identified in the Congressional hearings.

Judicial Recognition

In their interpretation of floodplain and environmental regulations, Federal and State courts have addressed many of the items noted in the course of the Congressional hearings and highlighted by experts. Floodplain regulations refer to any array of techniques designed to keep people away from floodwaters in contrast to structural measures (dams, dikes, levees, seawalls, and channel improvements) designed to keep floodwaters away from people. Floodplain regulation techniques include: comprehensive planning; building codes and building permits; floodplain zoning, subdivision regulations; site plan review; water supply, sewerage, drainage and erosion control regulations; utility location regulations, tidal and fresh water wetlands regulations; environmental regulations, set-back lines; acquisition and relocation.

A basic tension exists between the rights of the private property owner to use their property unencumbered by regulation; and the responsibility of all levels of government for the health, safety and well-being of their citizens. Floodplain regulations are widely accepted as an appropriate exercise of the police power. Regulations are presumed to be valid if they:

1) conform to and do not exceed the authority granted in enabling statutes;

2) adhere to the doctrine of reasonableness, i.e., do not unreasonably deprive property owners of all economic benefits; and

3) forbid arbitrary or discriminatory treatment, i.e., require equal treatment for similarly situated properties.

Appendix A traces some of the recent trends in judicial decisions relating to floodplain regulations. An effort was made to address, as specifically as possible, the concerns raised in the Congressional hearings and/or by the expert opinions.

In addition, court interpretations of the limits of regulations focused on the following items:

1) protection of lives and property, including the urban infrastructure;
2) preclusion of need for public expenditure for protective works and disaster relief;
3) preservation of groundwater recharge area; and
4) maintenance of environmental quality: ecosystems, natural resources, habitat, fish, and the production of nutrient use.

A clear trend in judicial interpretation of regulations designed to protect health, safety, and welfare of the public is to uphold such regulations.

Literature Search

A search of literature pertaining to floodplain management was conducted to identify potential effects of floodplain regulations. A recent example of an effort to identify specific effects of floodplain regulations is Warnick's paper on land values on or near regulated floodplains in Oregon.[1] In his review of the literature, he argues that previous attempts to deal with the general topic of land values and flood hazards were directed primarily at estimating land value changes resulting directly from flood control measures. Clarenbach, Knetsch, and Struyk were concerned with the impact of flood control on agricultural lands and land values.[1] Greenberg *et al*. examined methods for isolating the effects of flood protection on urban floodplains, while Boyet *et al*. addressed the impact of flooding itself on land values.[2]

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[1] Warnick, Growth Rates.

Shadman and Damianos took a different approach in the sense that they attempted to estimate the impact of structural and nonstructural flood hazard reduction alternatives on the sales prices of residential land.[3] Unfortunately, as Warnick points out, these authors were not able to distinguish the effects of a specific public policy such as flood hazard regulation from the effects of floods and flood hazards themselves. Although Warnick recognizes the difficulty in isolating the impacts of a specific policy, his analysis also falls somewhat short of the mark. As he admits:

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[1] F. Clarenbach, *Reliability of Estimates of Agricultural Damage from Floods*, Task Force Report on Water Resources and Power, vol. III (Commission on Organization of the Executive Branch of Government, 1954), pp. 1277-98; J. L. Knetsch, "The Influence of Reservoir Projects on Land Value," *Journal of Farm Economics* (1964); and R. S. Struyk, *Agricultural Flood Control Benefits and Land Values* (Alexandria, VA: U. S. Army Engineer Institute for Water Resources, 1971).

[2] E. Greenberg et al., *Analysis of Theories and Methods for Estimating Benefits of Protecting Urban Floodplains* (St. Louis: Institute for Urban and Regional Studies, Washington University, 1974); and W. Boyet et al., *The Impact of Flooding Upon Land Values in the Big River Basin* (Mississippi State University, Water Resources Research Institute, 1976).

[3] L. A. Shadman and D. Damianos, *Land Prices in Flood Hazard Areas: Applying Methods of Land Value Analysis*, Bulletin 95 (Blacksburg: Virginia Polytechnic Institute and State University, Virginia Water Resources Center, 1976).

> This study is not an attempt to isolate the effects of floodplain regulations on land value in terms of a specific dollar value per acre figure. Rather it is a trend analysis designed to compare the relative value appreciation rates of regulated and unregulated parcels with respect to the implementation of floodplain regulation on selected sites.[1]

This work demonstrates the difficulty of using a trend analysis to evaluate the effects of floodplain regulations. Since Warnick found only a slowing of the increase in land values in flood hazard areas, he could only conclude that the adverse effects of regulation, if any, were small relative to other forces operating on land values.

In contrast to these efforts to isolate specific effects, another body of literature was concerned with the identification of a more comprehensive list of potential effects. White and several of his colleagues have outlined a comprehensive list of potential economic effects of floodplain regulation ranging from benefits of open land and cutbacks in catastrophic potential to decreased dependency on structural works and a reduction in average annual damages.[2] He offers no empirical estimate of the size of these components, but he does argue that the need for such estimates is paramount. In conjunction with his flood hazard research assessment, he does estimate that the resources needed to provide accurate estimates over the following two years would be enormous.

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[1] Warnick, pp. 4-5.

[2] Gilbert F. White, et al., Changes in Urban Occupance of Floodplains in the United States, Department of Geography Research Paper No. 57 (Chicago: University of Chicago, November 1958).

The literature on the effects of floodplain regulations was not prolific. Much had been written on regulations generally and on the effects of adjustments to flood events. Indeed, the effects of regulations were most often presented in the context of mitigating or obviating the negative effects of flood episodes.[1] Such effects of regulations, therefore, are considered beneficial. The effects reported include:

1) reduction of population at risk, reduction in death and human suffering;
2) reduction of damages, property losses;
3) reduction in excavation, flood fighting, disaster relief, fire and police control efforts and their costs;
4) reduction in costs of adjustment, replacement, repair of infrastructure;
5) reduction of disruption of local government services;
6) reduction of interruption of business production of goods and services; and
7) reduction of transportation problems.

Willis, in particular, has identified a comprehensive list of direct, indirect, and intangible costs associated with flooding which are broken down by sector: agricultural, business, organization, personal, and public. She maintains that these costs are reduced through floodplain regulation, but introduces no quantitative methodology for supporting this hypothesis. This contention contrasts with the consensus of expert opinion which minimizes other than economic effects.

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[1] W. G. Sutton, "The Use of Floodplains," Military Engineer, Nov.-Dec. 1964, pp. 414-416; Tennessee Valley Authority, Oliver Springs Redevelopment Program, Planning Report No. 70-100 (Knoxville: 1968); J. D. Willis, Flood Insurance: Asset or Liability in Land Use Control, Emergency Planning Canada, Report 76-2 (Ottawa, Canada: April 1976); and Gilbert F. White et al., Flood Hazard in the United States: A Research Assessment (Boulder: Institute for Behaviorial Sciences, University of Colorado, 1975).

It should be noted that the effects described related to floodplain regulations and management techniques in general. In some cases, however, they specifically referred to NFIP regulations; and in most cases the controls described appear to resemble NFIP regulations.

Classification and Screening of Potential Effects

The identified potential effects of floodplain regulations were initially tabulated (see Figure 1, page 4) as they were perceived in the four sources. These effects were then classified under the general headings of Economic Effects, Social Effects, and Environmental Effects. The next step in the process was to screen these and select those which possibly could be evaluated in the case study areas. Four assessments were made in the screening process (see Figure 2, page 21). Potential effects were eliminated when it was determined that:

1) identified effects were not measurable;
2) data base needed for measurement was incomplete or nonexistent;
3) available data were too general for analysis of specific effects; and
4) data requirements were too extensive for scope of study.

Although data on flood losses generally were available, breakdowns into subcategories of land uses were not available. In these circumstances, assumptions as to the distribution of average annual losses were formulated and discussed with local and Federal (Corps of Engineers, Soil Conservation Service, FDAA) officials. Breakdowns for residential, commercial and industrial (combined) and public (plus institutional) sectors were carried throughout the study. Public facilities other than buildings were included in the latter category.

In some cases data were available at the national level but were not available for individual communities. In several instances, the national estimates were allocated uniformly to arrive at case study estimates. For example, average annual Red Cross costs were derived from national data. When yearly Red Cross expenditures for flood relief in the 1970s are compared with yearly flood losses, expenditures for relief approximate 0.3 percent of estimated losses. Of these expenditures, approximately 60 percent are for "relief" (mass care; food, clothing, and shelter; medical and nursing) and 40 percent for reimbursement of flood losses (building and repair; home furnishings; and occupational equipment and supplies). Thus, it was assumed that, on the average, Red Cross relief costs would be 0.18 percent (60 percent of 0.3 percent) of the total projected average annual damages in each scenario.

Similarly, average annual FDAA payments were derived from national data. Comparison of yearly FDAA payments for assistance in flood disasters in 1973-1974 ($272.7 million) with national yearly flood damages ($2,156.9 million) for the same period reveals that FDAA flood disaster assistance payments approximated 12 percent of estimated flood losses. FDAA authorities estimate that approximately 80 percent of the payments for assistance are for reimbursement of public damages and 20 percent for reimbursement of private (individual) damages. Thus, it was assumed that 12 percent of average annual damages in a case study would be reimbursed by the FDAA, 9.6 percent credited against public losses and 2.4 percent against private losses.

While population at-risk was carefully quantified, data on deaths, injury and illness were not complete. Moreover, they could not be annualized to conform to other modes of analysis. On the other hand, these items were correlated with the residential population at risk. Thus, effects of regulations on protection of lives were evaluated in terms of population at risk.

At the time of the case studies, it was not possible to quantify the environmental effects of regulations. Based on an assessment of environmental conditions in the case study areas, the effect of regulation and future development on such variables as water supply, water quality, ecosystem preservation, open space, recreation, and quality of life considerations could be discussed qualitatively. However, as comprehensive regional "208 plans" (EPA sponsored long range water quality management plans), transportation plans, open space plans, and water supply plans with their accompanying environmental assessments and environmental impact statements are completed, it will become more feasible to identify and quantify specific environmental values. Such a study is underway for the DuPage River in DuPage and Will Counties, Illinois. This study quantifies environmental values by drawing from the results of such plans which were available for northeastern Illinois.

Methodology

Willis, Mack, Baker and McPhee, and Litchfield have outlined approaches to be used in evaluating economic, social and environmental effects of floodplain regulations.[1] Willis highlighted the importance of distinguishing between national and local effects and of isolating the effects on various sectors of the community. Mack attempted to quantify the effects by focusing on benefits and costs, in addition to impacts that can be measured easily in dollar terms. An attempt was made to combine or weight the importance of the different kinds of effects.[1]

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[1] Willis, Insurance; Ruth P. Mack, "Criteria for Evaluation of Social Impacts of Flood Management Alternatives" (1974); "Assessment of Flood Management Alternatives Against Social Performance Criteria" (1975)(New York: Institute of Public Administration for the New England River Basin Commission); E. J. Baker and J. G. McPhee, Land Use Management and Regulation in Hazardous Areas: A Research Assessment (Boulder: Institute of Behavioral Sciences, University of Colorado, 1975); N. Litchfield, "What To Do With the Old Mint?" in Cost-Benefit Analysis in Urban Development (Berkeley: Real Estate Research Programs, University of California, 1962).

Mack's approach highlights the need for assigning relative importance to the various effects. Thus, its data demands make it difficult, if not impossible, to assign weights in more than one or two specific case studies. For this research effort, the approach of Litchfield seems more appropriate. Litchfield has used a straightforward approach. The costs and benefits of alternative decisions are enumerated and classified for the decision makers. The supplying of weights to the alternative decisions is left to the decision makers.

Mathematical Models

Falling between the analysis and quantification of a specific effect and the qualitative description of a comprehensive list of effects is a body of literature which includes formal mathematical models for estimating the effects of structural and nonstructural flood loss reduction measures. These efforts have been developed around simulation and mathematical programming techniques.[2]

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[1] Mack, "Criteria" and "Assessment" and Litchfield, "Old Mint," pp. 6-7.

[2] A useful comparison of these methods is contained in J. Sutton, W. Anderson, D. Carvey, B. Holmes, J. McDivitt and A. Miller, "Nonstructural Measures for Flood Damage Reduction," Working Paper No. 38 (Washington, D. C.: Natural Resource Economics Division, Economic Research Service, U. S. Department of Agriculture, July 1977).

The mathematical programming techniques are perhaps the most inflexible of the procedures, although with improved computer technology many realistic problems can be analyzed. Day and one of his recent students, Weisz, have developed and refined a programming model to allocate specific land uses to specific areas of the floodplain.[1] Using a productivity index that considers the flood hazard and the susceptibility of use to damage, the model selects the combination of land use activities, site elevation techniques, and flood proofing which maximizes the aggregate site rent, subject to predetermined land use goals, community growth expectations, and pre-project flood risk. North *et al*. tried to extend the methodology to include multiple goals, weighting each component according to its importance.[2]

The one feature of these models which sets them apart from other approaches is that they do not ask the question: "What is the effect of a particular structural or nonstructural measure?" Rather, they turn the analysis around and determine the measure or combination of measures that maximize some objective. While this may be an ideal way to develop floodplain management schemes, decisions are rarely made in such a comprehensive fashion.

The developers of this methodology recognize this fact and attempt to approximate an incremental decision approach by carefully constructing constraints on changes in land use implied by institutional land uses which do not respond to market forces, community development potential, and community goals. In some instances, these factors can be identified and in others they cannot. However, the problem of representing and measuring these constraints quantitatively is ever present and seriously limits the method's general applicability.

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[1] John C. Day, "A Recursive Programming Model for Nonstructural Flood Damage Control," *Water Resource Research*, Vol. 6, (October 1970) pp. 1262-71.

R. N. Weisz, *A Methodology for Planning Land Use and Engineering Alternatives for Floodplain Management* (Ph. D. thesis, Tucson: University of Arizona, 1972).

[2] R. M. North et al., *The Highest and Best Uses of the Oklawaha River Basin and Lake Rousseau for the Economy and the Environment* (Athens: Institute of Natural Resources, University of Georgia, 1976).

Despite the ability of many high speed computers to solve large linear programming problems, data limitations confound the general use of these exacting mathematical methods in floodplain management. Researchers are still limited by the accuracy with which the model's parameters can be estimated. As an example, Sutton et al. remark:

> In facing the problems encountered by other researchers--estimating economic rent--Day called upon tax assessment-sales value data in his case study area. Although he realized that economic rent must reflect flood losses, he was unable to determine empirically that the actual real estate market for floodplain property recognized it. He thus approximated rent by deducting all expected losses from estimated land market values.[1]

Data and information needs for these formal analyses are even more demanding than those used in analyzing one or two flood hazard mitigation measures in a less formal mathematical framework. One can seriously question whether the accuracy of the data warrants such sophisticated mathematical techniques.

Simulation Models

In constructing simulation models, as the name implies, researchers attempt to reproduce the essential characteristics of a socio-economic system in an experimental or laboratory environment so that the effects of an external stimulus on the system can be studied systematically. Because of the large number of complex relationships in local or regional economies, simulation models designed to examine the effects of structural and nonstructural flood loss mitigation measures often rely on high speed computers to perform many of the calculations. This computerization requires that the essential relationships be modeled mathematically. Because optimization is not inherently involved in the manipulation of the model, more complex relationships can be accommodated, thus enhancing the flexibility of the models. Once developed, the models can often be used over and over again to analyze a number of different policies.

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[1] J. Sutton et al., "Nonstructural Measures," p. 31.

Although varying in the degree of mathematical sophistication, the work of Arvanitidis, Lind *et al.*; Kunreuther; and James reflect the most recent attempts to simulate the effects of floodplain management alternatives.[1]

To illustrate, the Arvanitidis, Lind *et al*. simulation model "...allows planners to consider a variety of floodplain management plans, quantify the benefits, and determine their sensitivity to various parameters, different assumptions, and alternative policy decisions."[2] The essential components of the model include the calculation of economic rents, flood damages, and land values; the allocation of land use; and the benefit evaluation. Estimates of the essential parameters of the model are often difficult to obtain, particularly the ones related to economic rents and land values. Because the developers of these models also recognized the importance of environmental amenities, social factors, and costs of site development, construction and commuting, the effective use of the model depends on the ability of a knowledgeable planner to provide accurate input data (including general economic forecasts and the ultimate land use plans under alternative floodplain management schemes) and to interpret the output within the context of nonquantifiable socio-economic conditions.

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[1] N. W. Arvanitidis, R. C. Lind, et al., *Preliminary Review and Analysis of Flood Control Project Evaluation Procedures* (Ft. Belvoir, VA: Institute for Water Resources, Department of the Army, Corps of Engineers, 1970); N. W. Arvanitidis et al., *A Computer Simulation Model for Floodplain Development*, Part I (Ft. Belvoir, VA: Institute for Water Resources, Department of the Army, Corps of Engineers, 1972); H. Kunreuther et al., *Limited Knowledge and Insurance Protection: Implications for Natural Hazard Policy* (Washington, D.C.: NSF-RANN, 1977); L. D. James, *A Time-Dependent Planning Process for Combining Structural Measures, Land Use and Flood Proofing to Minimize the Economic Cost of Floods* (Palo Alto: Stanford University, 1964); L. D. James, "Non-Structural Measures for Flood Control," *Water Resources Research*, Vol. 1, No. 1 (1965); L. D. James, "Economic Analysis of Alternative Flood Control Measures," *Water Resources Research*, Vol. 3, No. 2 (1967).

[2] J. Sutton et al., "Nonstructural Measures," p. 22.

The models James applied sought to simulate optimality in real world nonlinear conditions and thereby avoid the linearity assumptions and requirements for unfamiliar data that make other models difficult to interpret. James did, however, recognize that an optimal plan for flood hazard mitigation could involve a combination of structural and nonstructural measures. James viewed flood damages as a cost which can be reduced through the application of a comprehensive flood control program.

On balance, these types of models can be used to forecast the type of land use activity and other consequences which might take place under a set of structural measures used in conjunction with governmental land use and other nonstructural hazard mitigation policies. They have failed to answer the question of what controls should be imposed. Although calculations are often facilitated through an interface with high speed digital computers, simulation models defined in their broadest sense need not be highly mathematical or completely quantifiable. The essential ingredients include an abstact model of an economy, combined with some way of tracing the effects of an external stimulus on the structure of the system. The effects can be traced with the help of formal mathematical relationships or in a more qualitative way through an appeal to theory and the power of logical reasoning.

Relevance to This Investigation

This study examines the effects of floodplain regulations on a variety of economic, social and environmental conditions. Since many of the effects will be felt in the future, some form of simulation methodology must be applied. The diversity of each floodplain area suggests the need to be site specific in the research. Because only a limited number of alternative land use policies is being examined in this research, the need for a capacity to conduct repeated experiments on the model is minimized. Because of data limitations, this effort seeks to quantify a small number of the selected effects rather than examine a comprehensive list of potential effects. Thus, the methodology developed for this study strives to be a balance between the more formal simulation approaches and the general conceptual frameworks frequently used to evaluate floodplain management problems.

Research Framework

An empirical, inductive approach was necessitated by the shortcomings of existing data on, and methods for evaluating, the effects of floodplain regulations. Perceived effects tended to be unsupported by empirical evidence.

The case study approach was adopted to meet this situation. Development of empirical data from selected case studies was intended to provide a base of information regarding the occupance of urban floodplains. The case study approach allows the analysis to be site specific for a range of flood conditions, community sizes, and geographic locations. Moreover, relationships of the effects of regulations can be analyzed. The linkages among regulations, population, housing, economic development potential, flood losses, and the flood hazard can be identified within the context of overall community development.

The following sections present the considerations behind the selection of the sample of case studies and the mode of investigation used in the case studies.

Selection of Case Study Areas

A large number of detailed field investigations was scheduled to maximize the quantity of empirical data assembled. Data were gathered from 23 selected case study areas but data from only 21 were included in the evaluation tables. The data collected for San Diego County, CA were not of detail comparable to those of other case studies and therefore were not included in the evaluation tables. Its regulatory policies, however, were included in the analysis along with the other case studies. The data for the 71 municipalities in Bergen County, NJ were gathered after the initial analyses for the other case studies were completed. The thrust of the Bergen County effort focused on the financial implications of floodplain locations and regulations. These data are more detailed than those gathered in the other case studies and could not be synthesized readily into the analyses.

The case study sites were selected to represent a range of geographic, flood, and economic conditions. The physical and regulatory characteristics represented in communities selected for case study investigation are summarized by Housing and Urban Development regions in Table 1. The sample is skewed in the direction of larger communities, in more urban, populous regions, where regional growth imperatives are great.

By choosing a large number of case studies, a broad range of community and flood conditions was represented. Thus the effects of regulations were viewed within a range of settings.

All the case study areas selected are urbanized. The rationale for this relates to the concentration of flood losses in urban centers. Goddard has shown that urban floodplains are limited to 0.56 percent of the nation's total area. The Water Resources Council estimates show that one-third of all flood losses are in urban areas.[1] Therefore, the potential for further development of the floodplains, and thus for increases in the exposure to flood risks, is greater in urban than rural areas. Finally, it is in the urban areas where floodplain regulations are more widespread and where their effects would be the most discernible. Figure 5 shows the locations of the case study communities.

The case studies were limited to communities which are participating in the National Flood Insurance Program (NFIP) and for which the 100-year flood is delineated. Further, there is an emphasis on communities which are participating in the Regular Program. This choice was made because flood hazard information is more detailed for Regular Program communities through their Flood Insurance Studies. Furthermore, it was assumed that communities with the most serious flood hazards are more likely to participate in the Regular Program at this time and would have floodplain regulatory experience. Overall, 9 out of the 10 HUD regions are represented by at least 2 case study areas. The only region not represented in the case studies is Region 10, comprising Alaska, Idaho, Oregon, and Washington. The urban flood losses in this region are relatively small compared to other regions.

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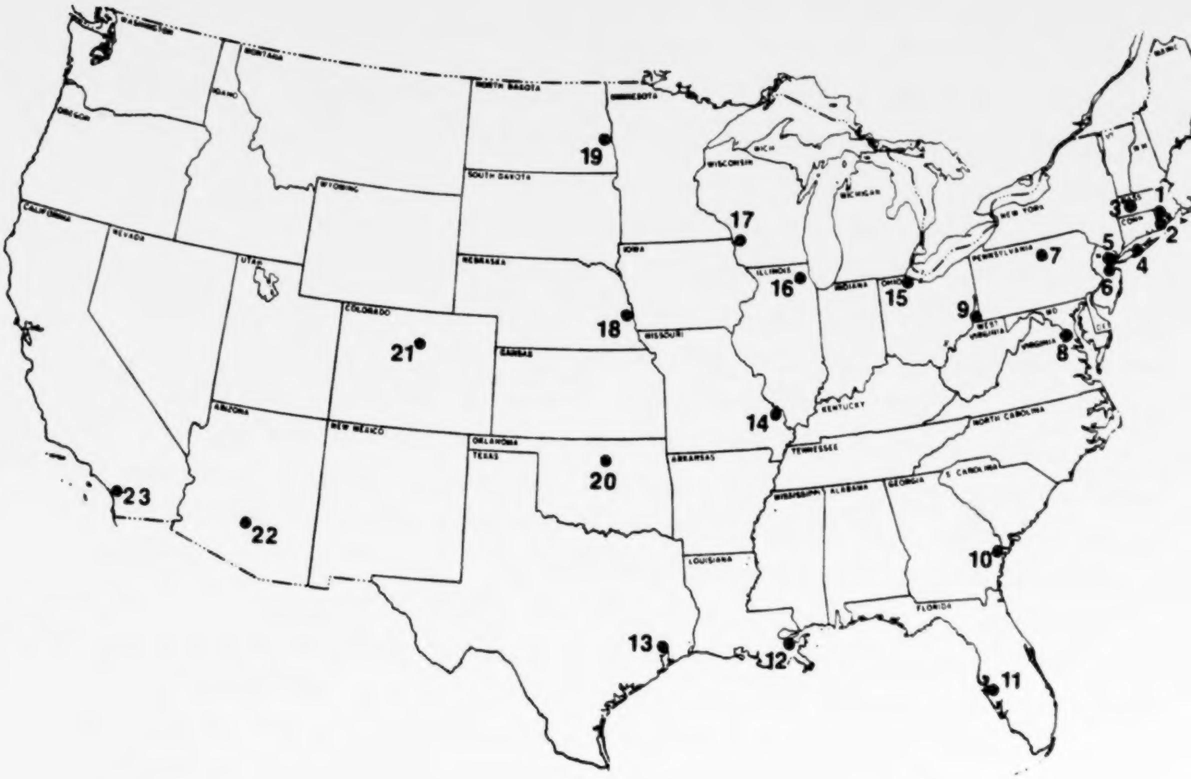
[1] Goddard, Evaluation, p. 25 and Water Resources Council, Estimated Flood Damages, p. 2.

Figure 5 : Location Map of Case Study Communities



1. Cranston, RI
2. Westerly, CT
3. Northampton, MA
4. Southampton, NY
5. Wayne Township, NJ
*6. Bergen County, NJ
7. Jersey Shore, PA
8. Prince George's County, MD
9. Wheeling, WV
10. Savannah, GA
11. Sarasota County, FL
12. Orleans Parish, LA
13. Harris County, TX
14. Cape Girardeau, MO
15. Toledo, OH
16. Palatine, IL
17. Prairie du Chien, WI
18. Omaha, NE
19. Fargo, ND
20. Tulsa, OK
21. Arvada, CO
22. Scottsdale, AZ
*23. San Diego County, CA

*Not included in all evaluations

Case Study Investigations

During field investigation, study teams experienced in planning, engineering, resource management, survey research, public administration, geography, and economics visited the case study areas. The research teams gathered information on community goals; social, economic, and environmental characteristics; trends in development patterns; growth trends; land use patterns and pressures; the type and perception of the flood hazard; the extent and character of flood damages; the history of floodplain adjustment to flood damages; and the evolution of floodplain policies including attitudes toward structural flood control measures. The information was gathered from census materials, planning documents, community files, newspapers, and various community reports. In addition, assessments were made of past decisions, especially those related to land use.

Interviews were held in each case study area with community informants and influentials including the mayor, city manager, tax assessor, planner, zoning administrator, building inspector, bankers, realtors, builders, floodplain occupants, newspaper editors, and representatives of social and environmental community groups. An initial group of knowledgable community informants was contacted for their views on these issues and to identify persons who were influential in floodplain issues. The standard initial panel of contacts is a feature of the Issue-Specific Reputational Method.[1] This method has proven useful in identifying a community's decision-making structure and in evaluating the relative significance of a particular issue (floodplain management) in the total scheme of communal issues. Overall, 481 persons were contacted and interviewed. Table 6 shows the number and type of contacts made. FIA regional staff and State coordinators were also used to identify key contacts for information and to provide background on issues.

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[1] Terry N. Clark, Community Structure, pp. 471-473.

An important aspect of the field investigations was the compilation and validation of data regarding community growth characteristics. Central to the projection of alternative regulatory scenarios is the adoption of a workable set of base data and assumptions regarding a community's growth potential. Interviewing persons in the community gave insight into current trends which allowed either the acceptance or modification of locally generated forecasts, both as to magnitude and location.

Projection Procedures

The major effects of floodplain regulations occur in the future. Unfortunately, floodplain regulations have not been in widespread use for a sufficiently long time to allow reviewing a community's experience to gain a definitive assessment of the economic, social, and environmental effects of such regulations. Even in those communities that had some experience with floodplain regulations, it still would have been necessary to compare effects of the regulations against what would have happened without the regulations. In order to perform with and without assessment it would have been necessary to compare a community with regulations to a comparable one without them.

The paucity of past experience with floodplain regulations requires the formulation of projection procedures to simulate their economic, social, and environmental effects. To do so, an approach based on hypothetical alternative future scenarios was adopted.

Table 6: Contracts by Category for Case Study Communities

Case Study Community	Persons Contacted														Case Study Total
	Elected Officials	Local Engineers Bldg.	Other Local Public	Assessors	Planners Zoning Housing	Econ. Devel. C of C	Non-Local Technical Sources	Developers Realtors	Bankers	Newspapers	Local Interest Groups	Environ.	Disaster Red Cross Civil Defense	Flood Hazard Area Residents	
Cranston, RI		1		1	2		3								7
Westerly, RI			2	1			8	1	1	1		3			17
Northampton, MA		1	1	1	2	1	11					2			19+
Wayne Township, NJ		2	2	1	2	1	1	4	1	2			1		17
Southampton Town, NY	5			1	2		2		2	2					14
Bergen County, NJ		9	7	8	4	1	7	4	10	1	2				53
Jersey Shore, PA	2	1	1	1	3	1	6	2	2	1	7			2	29+
Wheeling, WV	2	2		1	2	1	3	2	1	2			1		17
Prince Geo. Co. MD	3	4	5		3		2		1	1	2		1	2	24
Savannah, GA	2	4	3	1	5	1	4	4	2	1	2		2		31
Sarasota Co., FL	2	3	4	2	3	1	3	2	2	1	2	1	1		27
Toledo, OH		4	2	1	3	2	3	1	1						17
Palatine, IL	2	2	2	1	4	1	3	2	1	1	1			1	21
Prairie du Chien, WS	1		1	1	2	1	4	1		1		2			14
Orleans Parish, LA		1	2	2	5	1	2		1						14
Tulsa, OK	1	2	3	2	3	1	8	2		1	2			1	26
Harris County, TX	5	5	3	2	4	1	5	4	2		3	1			35+
Cape Girardeau, MO			2	1	1		6	1	3	2		1		1	18
Omaha Area, NB		1	1	1	4	1	5			1		1			15
Fargo, ND	3		4	1	2		3	2	2	2					19
Arvada, CO		3	4		3		2	1		1				1	15
Scottsdale, AZ		2	2		4	2	5	2	1	1					19
San Diego Co., CA		2			5	2	4								13
Total Sample	28	49	51	30	68	19	100	35	33	22	21	11	6	8	481+

+Public Meeting also held.

Formulation of Scenarios

To evaluate a range of regulatory actions, three scenarios were formulated. The three comprise a continuum from no regulations (Scenario I) to moderate regulations (Scenario II) to a combination of stringent preventive and corrective regulations (Scenario III). To avoid measuring the effects of varying degrees of regulation between communities, the application of the particular scenario in a case study community was assumed to be paralleled by the application of the same regulatory scenario throughout the nation. All regulations were assumed to be properly administered and enforced.

In Scenario I (Market Scenario) there are no floodplain regulations imposed on individuals or local government. The free market with its variations in preferences, price, supply, demand and local development policies and regulations governs future growth and development.

Scenario II assumes regulation of the floodplain analogous to the present National Flood Insurance Program as it is now being administered. The preventive aspects of floodplain regulations are carried out by altering construction practices to require new structures to be elevated so that the first floor is at or above the level of the 100-year flood and no new development is permitted in a designated floodway unless it is designed in a manner that will not raise the 100-year flood elevation. The corrective elements in terms of applying substantial improvement regulations are considered to be negligible.[1]

In Scenario III, a stringent regime of floodplain regulations is imposed. This includes the application of preventive aspects in terms of land use measures and the corrective aspects in terms of applying substantial improvement regulations through purchase and removal or other related action in a manner that will correct past unwise land use decisions. In this scenario, new structures are prohibited in the hazard area.

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[1] Sheaffer & Roland, Inc., Substantial Improvement.

The scenario approach was chosen because it allows projections to be made by using information on current variables and rates of change. Erickson has stated that:

> Scenarios are expedient, common-sense forecasts made with the help of empirical generalizations... [and are] of use in surmising about the consequences of an hypothesis given to hold true...[1] [and are particularly useful]
>
> ...in their ability to help provide insights into decisions needed for preventing, diverting, or encouraging the evolution of a social system at specific points in time.[2]

The scenario approach allows an evaluation of floodplain issues within the context of all community issues. It allows the analysis to focus on linkages of interactions among the diverse community elements and policies and to protect side effects as well as the evolution of the total system. Thus, the approach recognizes that a specific decision on any issue causes a progression of outcomes, some of which may stimulate the modification or reformulation of goals and policies. While scenarios are capable of iteration, outcomes are not predicted according to rigorous mathematical models. The alternative scenario approach is useful because it has the potential to produce strong images of the future. Such images can be communicated and allow private and public interests to get a clear idea of what could happen.

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[1] N. J. Erickson, Scenario Methodology in Natural Hazards Research (Boulder: Institute of Behavioral Science, University of Colorado, 1975) p. 12.

[2] Herman Kahn and Anthony J. Wiener, The Year 2000: A Framework for Speculation on the Next Thirty-Three Years (New York: MacMillan, 1967) p. 6, cited in ibid, p. 11.

Projections for each scenario can be based on available forecasts of population and land use for each case study community. The limitations of the data and the uncertainty of other variables disallow precise or formal prediction. Therefore, the projections for each scenario should be considered indicative. However, based on the local projections of population and land use, information and opinions received from local persons, and experienced judgments, reasonable conclusions about the range of future conditions could be made for the different scenarios in each case study area.

The analysis of the potential effects of floodplain regulations within each case study area was based on projections of key variables to 1980 and 1990, using 1975 conditions as a base. Scenarios for each community in 1980 and 1990 were developed especially emphasizing occupance, i.e., housing, population, and land use as the basis for simulating future economic, social, and environmental effects. Changes in these variables were projected under the three regimes of floodplain regulations. Flood losses were expressed in 1975 dollars.

Projection Methodology

The projection methodology was designed to adapt locally-generated projections, forecasts and predictions to the scenario structure. For each case study, locally-generated growth projections of population and land use were evaluated within a regional, State and national context. Past trends were examined on a comparative basis. Local projections were compared with projected sub-State, State and national trends, including such Federal analyses as Current Population Reports, Series P-25, and the Bureau of Economic Analysis OBERS Reports, Series E and F. Local persons in both the public and private sector were consulted to validate or modify these projections. The final responsibility rested with the case study teams who incorporated this information with their own assessments of the empirical evidence, e.g., the amount, location and nature of available land; the supply and demand for housing; the operation and future requirements of key industries; intra-regional and inter-regional competition for markets; cultural factors affecting net migration patterns; and the political motivations behind certain projections.

In each case study community the existing floodplain regulations were assessed to ascertain where on the regulatory continuum from Scenario I to Scenario III they fall. Once this was determined it became the operational scenario and the other scenarios were then formulated.

The projection of future floodplain land uses was based on known public and private programming, the application of certain planning standards (based on per capita or per dwelling unit demand) to occupance parameters, and certain locally-confirmed assumptions about residential density with respect to alternative regimes of regulation. The same procedure was conducted for projecting land uses in nonhazard areas. The sensitivity to various degrees of regulations was discussed with local persons. In general, differences in postulated density between hazard and nonhazard areas were found in only those case studies in which expert consensus held that land availability was diminished by more stringent regulations.

Residential flood losses were taken as a function of the currently observed percent of value of a structure and its contents (for a structure of a given type) lost on an average annual basis applied to projected units at an assumed value per unit (in constant prices). Similarly, tax base foregone or generated by a scenario was a function of the projected development and its value. These projections were modified to incorporate either added values or losses which would stem from the regulations. The rate of taxation was assumed to be constant for the entire 15-year period.

The scenario approach does provide some advantages because of its comparative nature. A similar band of error would be ascribed to all of the scenarios, therefore making it unnecessary to determine the exact amount of error. An error of a certain percent in one scenario is likely to be replicated to a similar extent in the same direction in the others. This feature preserves the analytical utility of the scenario method of projection by preserving the integrity of each scenario.

To facilitate the evaluations, all the economic effects of floodplain regulations were defined in average annual terms. Effects which were deemed to be one-time occurrences were translated into average annual terms by assuming that their impacts would be evenly distributed over a 20-year period. This time span was chosen as a normal period for the amortization of the building costs. Other one-time effects were similarly treated so that the basis for comparison and aggregation would be common to all effects. It should be noted that the evaluations were not made for the cumulative effects of regulations over time, but for the effects of regulation at specific points in the future.

Projected effects of alternative floodplain regulations were assessed on an average annual basis holding prices constant at the 1975 level rather than on the customary discounted present value basis. The purpose of the projections was to facilitate interscenario comparison at two points in the future.

By using average annual change in constant prices, the need for price projection while maintaining comparability was eliminated. Also, because the true nature of development is not uniform, greater development will occur in some years than in others. By using an average annual basis in constant dollars, this unevenness does not affect the analysis.

Application to the Nation

The case studies selected (Figure 5) can be viewed as a sample that is skewed toward large communities in which urbanization pressures are intense. In statistical nomenclature, the sample is defined as systematic rather than formally random or formally stratified. This decision was based on the observation that, in growth areas, the effects of floodplain regulations will be more discernible. Because the effects of many aspects of regulations will occur in the future, a static or no growth situation would not be a good situation to measure effects.

Ratios of occupance and flood loss parameters were computed to relate the sample of case studies to the urban areas of the nation. The proportion of housing units and population and land use area was fairly consistent. Thus, the aggregate sample could be taken to represent the nation's urban floodprone universe.

While the procedure is coarse and may involve a considerable degree of imprecision, this sample approach was pursued to project future changes in occupance and losses. The inclusion of many sparsely populated and static small towns in the case studies would have made the effects more difficult to evaluate. The reasoning was that where little development was being undertaken, the effects of regulations would be obscured. The skewness of losses in the direction of large urban areas indicates that the accuracy or conservativeness of this ratio will improve over time (because it is held constant). Third, this approach imparts a national urban perspective to the case study findings, in the absence of a more reliable national data base. Fourth, in sheer numbers of people, homes, acres and losses, the sample is so large that it is more representative of the actual occupance of the nation's flood-prone areas in scale than a more statistically refined sample. Thus, bearing in mind the reservation that it is difficult to represent a universe whose characteristics are poorly known, application of the sample results to the nation's urban floodplains can be considered a useful indication of the effects regulations will have in the nation's urban floodplains.

CHAPTER IV

CASE STUDY FINDINGS

In each study area, information was developed on the economic, social, and environmental conditions prevailing in 1975 and the forces that are likely to affect them in the future. The information, which was obtained through field investigations, is summarized in this chapter.

The chapter is organized into five sections. The first describes the current floodplain regulations in the study areas. The second presents the current socio-economic characteristics of residents, and environmental characteristics of the study areas. The third contains an estimate of the current level of flood damages. The fourth discusses the economic effects of regulations which are currently operating in the study areas. The fifth contains information on the status of the case studies in the National Flood Insurance Program.

Current Floodplain Regulations

Floodplain regulations were evaluated in each of the case study areas (see Table 1, page 6). Seventeen of the case study communities have Regular Program status in the NFIP and the others participate in the Emergency Program. (Bergen County was not included in this analysis.) The 100-year floodplain has been identified in all of the study areas although in Tulsa there is disagreement over the boundaries.

Regulations that exceed the minimum requirements of the NFIP were found in 10 case study areas. Seven study areas have adopted the minimum requirements. The remaining areas are in the Emergency Program and are presumed to be in the process of enacting appropriate regulations. Tulsa, because of the disagreement over the delineation of the 100-year floodplain, has enacted a building moratorium in the flood hazard area as a holding action until the disagreement is resolved. Nevertheless, Tulsa was recorded as a community which exceeded the minimum requirements.

A community can regulate land uses in a floodplain by adopting either an exclusive floodplain zone or by superimposing a floodplain overlay zone on existing zones. An exclusive floodplain zone has been instituted in 6 communities (indicated by a Z in Table 1). The floodplain zone supersedes previous zoning designations. For example, an area that was once zoned as residential is now zoned floodplain. In some communities, a portion of the floodplain is classified by local officials as a conservation zone. Sarastoa County has zoned parts of the 100-year floodplain as marine conservancy districts where no urban uses are permitted.

The implementation of either type of floodplain zone is through the exercise of the police powers of the states. The exercise of such powers must meet tests of reasonableness and flexibility. Flexibility is achieved in floodplain zones through amendments, variances, and special use permits.

With respect to habitable floor elevations, 8 of the case study areas require elevations equal to the 100-year flood level (indicated by a O in Table 1). In 9 study areas, buildings are required to be above the 100-year flood level. Of these 9 communities, 4 specify 2 feet or more above the 100-year base flood level (Westerly, Southampton, Prairie du Chien, and Arvada). The communities in the Emergency Program currently do not specify elevations.

The administration of floodplain regulations is carried out through a building permit system in 18 communities. In 12 of these, the building codes contain provisions specifically related to construction in the floodplain. In coastal communities, where hurricanes pose a serious threat, construction requirements include beachfront setbacks and structural standards used in conjunction with elevation requirements to meet the stress of added wind and wave action.

Subdivision regulations are used by 12 communities to regulate the runoff from urban development. Such regulations included stormwater detention, compensatory storage to offset the effects of fills in floodplains, and restrictions on the rate of runoff, e.g., 0.15 cfs per acre.

A density transfer scheme is used in 5 communities to encourage developers to preserve open space in floodplains. Units permitted under normal density requirements are transferred from the hazard portion of a tract of land to the nonhazard portion. This tacitly exchanges increased net density in the nonhazard area for the preservation of open space in the hazard area. The overall density of the entire parcel is held constant. In Palatine, for example, this approach has resulted in a number of managed floodplain areas with dwellings on the fringes of lakes and lagoons with common acreage maintained as open space. Residents have found the value of their properties in these areas has increased. Other areas where this regulatory tool was used successfully include Wayne Township, Prince George's County, Arvada, and Scottsdale. In Scottsdale, the city has been adding the 100-year floodplain to its greenbelt system by securing easements. Prince George's County is hopeful this technique will also result in an upgrading of housing and an increase in riverine open space which is called for in their wedges (open space) and corridors (developed areas) land use plan.

In 6 case study areas, the 100-year floodplain is broken down into a floodway and a flood fringe area. When a floodway is defined, regulations prohibit development which would increase the level of the 100-year flood above a predetermined level. The NFIP minimum requirement is less than a 1-foot rise. In Wayne Township, suggested State regulations would prohibit fill which would raise the base flood level by more than 0.2 feet. Toledo imposes a 0.5-feet standard through the Ohio Department of Natural Resources regulations. Several other communities have indicated that they are in the process of delineating the floodway and intend to regulate further development.

Wetlands conservation requirements prevent development in some flood hazard areas. For example, New York (Southampton), Maryland (Prince George's County), and Florida (Sarasota County) regulate wetlands. Maryland also uses its Scenic River designation to prohibit development in many areas. Coastal zone management regulations are in effect or in the implementation phase in Rhode Island (Westerly), New York, Florida, Louisiana (Orleans Parish), and Texas (Harris County). In Texas, for example, building standards are being developed to mitigate damages from wind, and waves and debris associated with storm events.

A variety of techniques are used to achieve floodplain regulation in the case study areas. Even in some of the fastest growing communities, strict regulations have been adopted.

Floodplain regulations as now practiced by those communities in the NFIP Regular Program use the minimum requirements of the NFIP as a base or point of departure. Thus, the current experience may be viewed as moving from Scenario II (moderate regulations) toward Scenario III (stringent regulations). As previously stated, regulations in 10 of the case studies exceeded the NFIP minimum requirements which are similar to Scenario II.

Current Occupance Characteristics

Housing, population, land use, socio-economic, and environmental characteristics of the case study areas in 1975 provide base data from which the future effects of regulating scenarios are projected. The following sections discuss differences in settlement patterns and socio-economic factors between the 100-year floodplains and the remainder of the study areas.

The number of housing units, businesses, public buildings and other structures existing in the 100-year floodplain and the nonhazard areas of the case study communities was estimated using available data supplemented with field observations. The initial effort was to divide the case study areas between the 100-year floodplain and the nonhazard area. The most recent municipal records were used to gain information on occupance. Building permit data were used to supplement aerial photographs and census data. In all cases, field observations were conducted to verify the data and to assess the degree to which new and existing structures in the 100-year floodplain had been elevated.

Housing

Dwelling units located within the 100-year floodplain were estimated from census information, areal photographs and planning documents. They totaled 162,800 or 13.5 percent of all housing units in the sample study areas in 1975. Dwelling units that are located below the level of the 100-year flood stage total 87,400. Thus, there are 75,400 dwelling units located within the flood hazard area but which are elevated above the 100-year flood elevation. The dwelling units at risk account for 7.2 percent of the total dwelling units (see Table 7).

Table 7 : Distribution of Dwelling Units in the Case Study Communities, 1975.
(Rounded to Nearest 100)

Case Study Community	Total Study Area	Dwelling Units[a]				
		Flood Hazard Area	Percent of Total	At-Risk[b]	Percent of Total Study Area	Percent of Flood Hazard Area
Cranston, RI	22,600	1,000	4.4	900	3.9	90.0
Westerly, RI	7,600	700	9.2	700	9.2	100.0
Northampton, MA	9,300	100	1.1	100	1.1	100.0
Wayne Township, NJ	14,200	1,900	13.4	1,900	13.4	100.0
Southampton Town, NY	18,000	3,000	16.7	3,000	16.7	100.0
Jersey Shore, PA	1,900	1,000	52.6	1,000	52.6	100.0
Wheeling, WV	13,000	5,200	40.0	5,200	40.0	100.0
Prince Geo. Cty., MD	222,000	1,800	0.8	700	0.3	38.9
Savannah, GA	39,600	2,900	7.3	1,000	2.5	34.5
Sarasota County, FL	22,300	14,300	64.1	3,900	17.5	27.3
Toledo, OH	137,000	7,500	5.5	5,500	4.0	73.3
Palatine, IL	7,800	700	9.0	700	9.0	100.0
Prairie du Chien, WI	2,100	200	9.5	200	9.5	100.0
Orleans Parish, LA	220,700	81,400	36.9	32,600	16.4	40.0
Tulsa, OK	135,000	5,800	4.3	5,000	3.7	86.2
Harris County, TX	110,900	24,700	22.3	20,400	18.4	82.6
Cape Girardeau, MO	11,200	500	4.5	500	4.5	100.0
Omaha Area, NB	136,800	1,600	1.2	1,600	1.2	100.0
Fargo, ND	19,800	4,900	24.7	800	4.0	16.3
Arvada, CO	23,000	1,400	6.1	1,200	5.2	85.7
Scottsdale, AZ	32,400	2,200	6.8	500	1.5	22.7
Sample Total	1,207,200	162,800		87,400		
Sample Mean			13.5		7.2	53.7

[a] Housing data for 21 case studies. (Bergen and San Diego Counties excluded due to lack of comparable data.) Terms used are defined as in the 1970 U.S. Census of Population and Housing.

[b] At-Risk = Subject to 100-year flood elevation (at grade).

The analysis of substantial improvements referred to earlier reported a slightly higher percentage (7.9 percent) for total floodplain dwelling units at risk than what is reported here.[1] The differences in the estimates are due to subsequent changes in Fargo, North Dakota. Completion of a channel improvement project for a county drain will have an estimated effect of removing 90 percent of 1975 floodplain structures from the 100-year floodplain. In this study, it was assumed that the flood control project was completed. Thus, the number of dwelling units at risk in Fargo was reduced to 800 from the 4,900 reported in the earlier study. Thus, the total number of units at risk and their percentage of the total housing stock are lower in this investigation.

There was a wide variation in the concentration of dwelling units in the floodplain (see Table 7). Communities with more than 30 percent of their dwelling units in the 100-year floodplain include Jersey Shore, Wheeling, Sarasota County, and Orleans Parish. On the other hand, there are 13 case study areas in which less than 10 percent of the dwelling units are within the 100-year floodplain. In 6 of these areas, less than 5 percent of the dwelling units are in the floodplain--Cranston, Northampton, Prince George's County, Tulsa, Cape Girardeau, and Omaha. There are only 10 case study areas with less than 5 percent of their dwelling units at risk.

Population

Floodplain population is closely related to floodplain housing. The hazard area population, for the combined case studies is 480,500 or 13.8 percent of the total population. Because of elevation, however, the population at risk is only 266,500 or 7.6 percent of the total population (see Table 8). Of the 21 case study areas evaluated (San Diego and Bergen County are not included in these analyses), 10 had 5 percent or less of their population at risk.

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[1] Sheaffer & Roland, Substantial Improvement, Table A-13, p. A-16.

Table 8 : Distribution of Population in the Case Study Communities, 1975. (Rounded to Nearest 100)

Case Study Community	Population[a]					
	Total Study Area	Flood Hazard Area	Percent of Total	At-Risk[b]	Percent of Total Study Area	Percent of Flood Hazard Area
Cranston, RI	76,300	3,400	4.5	2,900	3.8	85.3
Westerly, RI	22,800	4,000	17.5	4,000	17.5	100.0
Northampton, MA	32,000	300	0.9	300	0.9	100.0
Wayne Township, NJ	50,200	5,800	11.6	5,800	11.6	100.0
Southampton Town, NY	90,000	11,500	12.8	11,500	12.8	100.0
Jersey Shore, PA	5,200	2,900	55.8	2,900	55.8	100.0
Wheeling, WV	46,500	13,700	29.5	13,700	29.5	100.0
Prince Geo. Cty., MD	674,800	4,600	0.7	2,000	0.3	43.5
Savannah, GA	118,600	9,800	8.3	3,500	2.8	33.7
Sarasota Couty, FL	51,800	31,400	60.6	8,600	16.6	27.4
Toledo, OH	377,000	22,800	6.1	16,300	4.3	71.5
Palatine, IL	26,500	2,300	8.7	2,300	8.7	100.0
Prairie du Chien, WI	5,700	600	10.5	600	10.5	100.0
Orleans Parish, LA	564,300	239,400	42.4	95,800	17.0	40.0
Tulsa, OK	348,800	15,900	4.6	15,000	4.3	94.3
Harris County, TX	366,000	81,600	22.3	67,400	18.4	82.6
Cape Girardeau, MO	36,300	1,800	5.0	1,800	5.0	100.0
Omaha Area, NB	382,100	4,700	1.2	4,500	1.2	95.7
Fargo, ND	55,800	13,600	24.4	2,200	3.9	16.2
Arvada, CO	88,400	4,900	8.5	4,200	9.0	85.7
Scottsdale, AZ	70,100	5,500	8.1	1,400	2.1	25.5
Sample Total	3,489,200	480,500		265,500		
Sample Mean			13.8		7.6	55.3

[a] Population data for 21 case studies. (Bergen and San Diego Counties excluded due to lack of comparable data.) Terms used are as defined in the 1970 U.S. Census of Population.

[b] At-Risk = Subject to 100-year flood elevation (at grade).

Land Use

The existing land use in the case study areas was analyzed to establish a base upon which future land use projections are built. Development in both the 100-year floodplain and the nonhazard area was measured and evaluated.

The number of floodplain acres and extent of development in the case study communities are tabulated in Table 9. The aggregate floodplain comprised about 20 percent of the total combined study areas. It accounted for 12 percent of all development in the case study communities.

The floodplains of the sample communities were generally less developed than the nonhazard areas. Only 17.8 percent of the total floodplain acreage was developed in contrast to 29.4 percent of the nonhazard area acreage.

There are 5 communities that have a high rate of development in the floodplain (more than 50 percent). Included are older riverine-oriented communities that were related to river transportation or river crossings. Examples of such communities include Jersey Shore, Wheeling, and Prairie du Chien. Also included are communities that have expanded recently and in which there is a cultural/aesthetic reason to develop in floodplains due to the relative absence of water views, topographical relief, and vegetation outside the floodplain. Tulsa and Sarasota County are examples.

A possible explanation for these development patterns is that an awareness of the flood hazard and the availability of nonhazard developable land has led to a slower rate of development in the 100-year floodplain than in the community as a whole. Part of the ex-

Table 9 : Development in Case Study Communities, 1975

Case Study Community	Total Acres a/ Flood Hazard Area	Non-Hazard Area	Total Study Area	FHA as Percent of Total Area	Percent Developed FHA	NHA	FHA Development as Percent of Total Development
Cranston, RI	1,710	15,600	17,310	9.3	41.5	50.7	8.2
Westerly, RI	3,700	15,300	19,000	19.4	12.4	29.7	9.2
Northampton, MA	4,000	18,200	22,200	18.0	5.0	26.4	4.0
Wayne Township, NJ	2,700	13,500	16,200	16.7	46.3	79.6	
Southampton Town, NY	NA	NA	NA	NA	NA	NA	NA
Jersey Shore, PA	270	450	720	37.5	88.9	68.9	43.6
Wheeling, WV	1,400	5,680	7,080	19.7	71.4	59.9	22.7
Prince Geo. Co., MD	20,000	289,340	309,340	6.5	15.0	31.9	3.1
Savannah, GA	2,210	13,430	15,640	14.1	47.1	89.8	7.9
Sarasota Co., FL	14,220	9,110	23,330	61.0	60.3	73.5	56.1
Toledo, OH	3,350	48,160	51,510	6.5	33.4	71.6	3.1
Palatine, IL	740	3,440	4,180	17.7	25.6	76.7	6.7
Prairie du Chien, WS	520	1,640	2,160	24.1	63.5	57.9	25.7
Orleans Parish, LA	96,270	29,350	126,620	76.6	18.7	63.5	49.1
Tulsa, OK	6,100	163,350	169,450	3.6	57.9	41.3	5.0
Harris County, TX	158,500	534,400	692,900	22.9	9.5	10.1	21.7
Cape Girardeau, MO	3,500	9,500	13,000	26.9	41.4	54.7	21.8
Omaha Area, NB	7,600	105,700	113,300	6.7	14.5	48.1	2.1
Fargo, ND	3,330	12,620	16,000	21.1	37.0	65.5	13.1
Arvada, CO	1,200	15,800	17,000	7.1	29.2	83.4	6.2
Scottsdale, AZ	1,660	53,600	55,260	3.0	30.1	16.7	5.3
SAMPLE TOTAL	333,100	1,358,100	1,691,200				
SAMPLE MEAN				19.7	17.8	29.4	12.3

a/ Land use data for 20 case studies. (Southampton Town excluded due to lack of comparable data.) Developed defined in text.

planation may also lie in the fact that because of physical constraints in some areas, some floodplains are comparatively more expensive to develop, and thus are the last lands to be developed. While this practice of development has helped to mitigate flood losses, the potential for increasing future flood losses is high. On the other hand, this information shows that the supply of undeveloped land outside the 100-year floodplain is abundant; in no community was more than 80 percent of the nonhazard area developed.

As previously stated, only 17.8 percent of the 100-year floodplain and 29.4 percent of the nonhazard area were developed at the time of the field investigations. The distribution of this development among the general land use classifications of residential, commercial, industrial, public, and urban support facilities (transportation, communications, and utilities) is tabulated in Table 10 for each case study area.

A comparison of land uses in the floodplain with nonhazard portions of the case studies shows that residential use accounts for less than 9 percent of the aggregate floodplain land or about 48 percent of total floodplain development. In comparison, residential uses account for nearly 16 percent of the aggregate nonhazard area, or 53 percent of total development in nonhazard areas.

Commercial uses account for slightly more than 2 percent of the sample's floodplain and slightly less than 2 percent of the nonhazard area. In Wayne Township, Wheeling, and Sarasota, commer-

Table 10: Distribution of Developed Land Uses in Floodplains (FHA) and Nonhazard Areas (NHA), 1975 (Expressed as Percent of Development in the Respective Floodplains and Nonhazard Areas)

	DEVELOPED											
CASE STUDY COMMUNITY	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		PUBLIC		TCU		TOTAL	
	FHA	NHA	FHA	NHA	FHA	NHA	FHA	NHA	FHA	NHA	FHA	NHA
Cranston, RI	12	31	3	2	8	1			18	16	41	51
Westerly, RI	8	18	2	2	*	1	1	1	2	9	12	30
Northampton, MA	1	12	*b	*b	*b	5b	3	3	3	6	5	26
Wayne Township, NJ	16	47	11	4	3	19	a	a	17	11	46	80
Southampton Town, NY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Jersey Shore, PA	56	41	3	3	2	17	4	1	13	20	89	72
Wheeling, WV	24	30	12	4	9	2	4	4	20	19	71	60
Prince Geo. Cty., MD	3	13	a	a	a	a	16	17	a	a	15	32
Savannah, GA	24	63	4	3	9	2	4	4	8	19	47	90
Sarasota Cty., FL	42	51	18	22	a	a	a	a	a	a	33	74
Toledo, OH	17	46	1	6	4	11	5	5	8	3	33	72
Palatine, IL	16	53	3	6	0	4	12	13	a	a	25	77
Prairie du Chien, WS	12	16	2	3	6	5	10	10	34	21	64	58
Orleans Parish, LA	7	25	2	2	2	9	4	11	7	17	19	64
Tulsa, OK	28	21	7	4	10	3	1	1	10	12	58	41
Harris County, TX	6	8	1	1	3	2	a	a	a	a	10	10
Cape Girardeau, MO	5	34	6	3	16	*	4	5	13	13	41	56
Omaha Area, NB	5	24	2	3	2	5	4	4	1	12	15	48
Fargo, ND	16	17	7	5	2	1	7	8	11	35	37	66
Arvada, CO	27	29	2	1	1	*	a	a	a	a	33	33
Scottsdale, AZ	19	14	3	2	2	*	1	1	a	a	30	17
SAMPLE MEAN	8.6	15.9	2.1	1.8	2.6	2.5	1.5	4.8	3.0	4.2	17.8	29.4

* less than 0.5 percent

a Included under other categories of developed land uses

b Commercial/Industrial combined

NA Not Available

cial development is a significant use in the floodplain. In terms of the overall sample, commercial uses account for about 12 and 6 percent of the development in the floodplain and nonhazard areas, respectively.

Industrial use accounts for less than 3 percent of the floodplain land use and virtually the same in the nonhazard area. Communities in which industrial land use is a relatively high percentage of the floodplain development include Cranston, Wheeling, Savannah, Cape Girardeau, and Tulsa.

Public uses of the floodplain include public buildings, such as municipal offices, schools, public works facilities, indoor recreation structures and health centers. Subsumed under this category are similar activities operated by not for profit owners. Public facilities in the floodplain comprise less than 2 percent of its development. In contrast, nearly 5 percent of the nonhazard area houses public uses. Public facilities constitute an unusually large share of floodplain development in Prince George's County, Palatine and Prairie du Chien. In Prince George's County, this is due to proximity to the nation's capital and the large amount of public holdings in the floodplain; the latter two communities are very small with disproportionately large floodplains and disproportionately high development in them.

Urban support facilities which include transportation, communication, and utility facilities (TCU) account for 3 percent of the floodplain and 4 percent of the nonhazard area. In communities such as Cranston, Wayne Township, Jersey Shore, Wheeling, Prairie du Chien, Tulsa, Cape Girardeau, and Fargo more than 10 percent of the floodplain development is devoted to these uses. Interstate highways contribute significantly to these totals.

A National Urban Perspective

The sample case study communities can be used to understand the universe of floodprone communities as reported by the Federal Insurance Administration. The sample can be related to the nation in terms of housing, population and developed land.

Of the 1,207,200 dwelling units in the sample, 162,800 or 13.5 percent were situated in the floodplain. The FIA reported 6,238,000 one to four family dwelling units in the floodplains of all NFIP communities, which are virtually all urban places.[1] This estimate can be adjusted by applying the housing distribution rates presented in the 1975 Annual Survey of Housing. The Survey estimated that one to four family units comprise 84.8 percent of occupied units. The adjusted universe of occupied floodplain dwelling units is then 7,356,000. FIA does not estimate units at risk. If the 53.7 percent (87,400 at risk ÷ 162,800 in the floodplain) at risk factor is applied to this adjusted universe, 3,950,000 housing units are at risk in the nation. The case study sample, therefore, is assumed to account for 2.21 percent of that estimated universe of urban dwelling units at risk as it does for all floodplain dwelling units.

In other research, the universe of floodplain housing at risk was estimated at 4.5 million units.[2] That research was based on applying the 7.5 percent at risk rate noted previously (see page 87) to the estimated 61.3 million dwelling units in the nation with first floor elevations at or near grade. The estimate of 3.95 million units at risk developed in this report (7.36 million for all floodplain dwelling units) is a national estimate for the 15,568 communities participating in the NFIP.

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[1] FIA, Status Report, 30 September 1977.

[2] Sheaffer and Roland, Substantial Improvement, pp. 36-37.

If one were to apply the 7.2 percent at risk rates to the nation's entire housing stock (61.3 million) an estimated 4.41 million units would be at risk. The 460,000 difference between 4.41 million units and the 3.95 million units estimated in this research represents the number of housing units at risk in communities not participating in the NFIP. These units would therefore presumably not be in urban places.

The sample is skewed toward larger urban areas in terms of population. About four-fifths of the sample communities have populations of between 20,000 and 500,000 (see Table 11). Only about one-fifth of Regular Program communities in the NFIP are in this category. This skewness was deliberate, allowing research to focus on communities where change is frequent enough and large enough to shed light on the effects of floodplain regulations.

Assuming, as was done above, that NFIP communities are virtually all urban places, and that communities outside the NFIP are essentially all rural, the sample population can be expressed as a fraction of the nation's urban floodplains. Although a comparable disaggregation of all NFIP communities was not available, an aggregate 175.2 million was recorded as the population of all NFIP communities as of 30 March 1976.[1] This indicates that the sample population of 3,489,200 represents 1.99 percent of the population universe of NFIP floodprone communities.

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[1] FIA, Status Report, 30 September 1977.

Table 11: Distribution of Flood-Prone Communities by Total Community Population

Total Population	Sample Case Studies[c]		NFIP Regular Program[a]	
	Number	Percent	Number	Percent
0 - 1,000	0	0.0	154	16.9
1,001 - 5,000	0	0.0	307	33.8
5,001 - 20,000	2	9.5	255	28.1
20,001 - 50,000	5	23.8	108	11.9
50,001 - 100,000	7	33.3	46	5.1
100,001 - 500,000	5	23.8	36	4.0
500,001 - 1,000,000	2	9.5	1	0.1
Over 1,000,000[d]	0	0.0	2	0.2
Total	21	99.9[b]	909	100.1[b]
Total Population	3,489,200		24,160,500	
Median	75,000		4,972	
Mean	166,152		4,859	

[a] Federal Insurance Administration, National Statistical Survey, 30 June 1977. Regular Program communities reported were 1,014; 105 were not classified in any population group. Comparable data for Emergency Program communities were not available.

[b] Sum differs from 100.0 percent due to rounding.

[c] Bergen and San Diego Counties not included.

[d] Midpoint of final class interval assumed to be 2 million.

Similarly, in terms of the 100-year floodplain, the sample is weighted toward communities with large floodplain areas. As presented in Table 12, the median area of the sample's floodplain is about 3,300 acres, while the median for all communities participating in the NFIP is 489 acres. The means are 16,555 acres and 1,648 acres, respectively. When only the communities in the Regular Program of NFIP are considered, the median increases slightly to 514 acres. The total acreage of the floodplains of the sample communities, 331,100 acres, comprises 1.37 percent of the flood hazard area of all NFIP communities (24,132,800 acres).

On the average, 19.7 percent of the land area in the study communities was estimated to be in the 100-year floodplain. This exceeds substantially two other estimates of the percentage of urban areas in our nation's floodplains (e.g., the 1967 estimate made by the U. S. Department of Agriculture of 4.6 percent, and the 1973 estimate made by the Corps of Engineers of 5.5 percent).[1] FIA has estimated that 9.4 percent of the area in Regular Program communities is in the 100-year floodplain.[2] Goddard's 1973 estimates, based on another sample of urban communities, is much close to what was found in this study. In his sample of communities, the floodplain constituted 16.2 percent of the total land area.[3]

Economic and Social Characteristics of the Population

As with many other public programs, floodplain regulations have been thought to potentially alter the socio-economic complexion of an entire community or part of it. By the same toker an entrenched pattern of existing socio-economic characteristics

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[1] Cited in Goddard, Evaluation.

[2] FIA, Status Report, September 1977.

[3] Goddard, Evaluation, p. 21.

Table 12: Distribution of Flood-Prone Communities by Size of Floodpl

Flood Hazard Area (in acres)	Sample Case Studies[b]		NFIP[a]			
			Total		Regular Progr	
	Number	Percent	Number	Percent	Number	Perce
>16,000[d]	3	14.3	158	1.1	37	3.2
9,600 - 15,999	1	4.8	121	0.8	6	0.5
6,400 - 9,599	2	9.5	202	1.4	20	1.7
4,800 - 6,399	1	4.8	280	1.9	26	2.3
3,200 - 4,799	5	23.8	657	4.5	47	4.1
1,920 - 3,199	2	9.5	1,087	7.4	86	7.4
1,280 - 1,919	3	14.3	903	6.2	63	5.5
640 - 1,279	1	4.8	1,641	11.2	151	13.1
<640	3	14.3	9,591	65.5	719	62.2
Total	21	100.1[c]	14,642	100.0	1,155	100.0
Median	3,300 acres		489 acres		514 acres	
Mean	16,555 acres		1,648 acres		2,681 acres	

[a] Federal Insurance Administration, National Statistical Survey, 30 June 1977.

[b] Bergen and San Diego Counties not included.

[c] Sum exceeds 100.0 percent due to rounding.

[d] Midpoint of class interval assumed to be 50,000 acres.

may make adjustment or changes in response to regulations a very difficult process. Characteristics that are apt to be particularl important are racial composition; size of the family and dependent population (persons who are under 18 and over 65 years of age); and income (Table 13). That is, for families with the same income, the ability to maintain a certain standard of living and adjust to government regulations probably falls as family size and the number of dependents rise. Therefore, it is important to determine how regulations in a given socio-economic context affect the standard of living of floodplain residents compared with nonfloodplain residents.

The nonwhite population in the case study communities, excluding Orleans Parish, average 12.6 percent of the total, which is only slightly lower than the 13.7 percent proportion of nonwhite population in the nation's urban areas. (The addition of Orleans Parish, which represents nearly 20 percent of the total sample population, raises the nonwhite population percent to 18.9.) Contrary to an original hypothesis, the proportion of nonwhites in the floodplain is much lower, averaging only 6.4 percent (see Table 13).

In several case study areas, the floodplain locations were highly valued as homesites due to their scenic attributes and an abundance of trees, e.g., Toledo, Tulsa, and Omaha. These floodplains were occupied largely by white population.

The age distribution, as reflected in the size of the dependent population, in the sample of communities is also quite close to the United States norm (see Table 13). For the country as a who the dependent population (e.g., the proportion of the population

Table 13: Economic and Social Characteristics of the Population in the Case Study Communities

Case Study Community	Population (1970) Percent: Non-White a/ FHA	Non-White a/ NHA	Dependent b/ FHA	Dependent b/ NHA	Dwelling (1970) Percent: Single Family FHA	Single Family NHA	Owner Occupied FHA	Owner Occupied NHA	Vacant FHA	Vacant NHA	Mean Value ($000) FHA	Mean Value ($000) TSA	Household Size (1975) FHA	Household Size (1975) NHA	Mean Family Income ($000) (1970) c/ FHA	Mean Family Income ($000) (1970) c/ TSA
Cranston, RI	0.8	0.8	43	43	69.3	64.8	73.9	70.0	1.2	2.5	30	30	3.40	3.40	19.3	19.3
Westerly, RI	NA	NA	NA	NA	100.0	NA	e/	NA	f/	f/	45	34	5.71	2.72		
Northampton, MA	0.0	1.0	39	39	100.0	NA	e/	NA	3.3	NA	20	26	3.00	3.20		
Wayne Township, NJ	0.4	0.4	44	43	89.0	84.0	76.0	81.2	3.0	1.0	33	49	3.05	3.61	15.6	20.7
Southampton Town, NY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.83	5.23		
Jersey Shore, PA	1.0	0.0	53	54	52.0	72.0	52.0	68.0	2.0	5.0	13	13	2.90	2.56	11.8	11.8
Wheeling, WV	6.6	4.0		47	55.0	61.0	51.6	54.9	7.6	5.3	15	30	2.63	4.21	8.2	11.7
Prince Geo. Co., MD	16.0	15.0	44	44	42.0	45.3	47.8	48.3	3.0	2.9	34	35	2.56	3.04		19.7
Savannah, GA	32.0	45.0	47	53	80.0	66.0	56.0	NA	2.8	NA	18	19	3.38	2.96		11.9
Sarasota Co., FL	1.4	1.4	54	54	d/	d/	d/	d/	f/	f/	26	26	2.20	2.55	13.7	13.7
Toledo, OH	1.1	13.8	45	45	70.4	64.8	62.2	62.9	3.4	3.8	30	25	3.04	2.74		
Palatine, IL	d/	d/	48	48	100.0	NA	e/	NA	d/	d/	48	48	3.29	3.41	28.1	28.1
Prairie du Chien, WS	0.1	0.1	54	54	84.0	84.0	70.0	71.0	8.0	6.0	11	21	3.00	2.68		
Orleans Parish, LA			48	48	d/	d/	d/	d/	8.0	NA	34	34	2.94	2.33	13.2	13.2
Tulsa, OK	0.0	13.3	39	43	64.0	NA	62.0	NA	6.0	NA	24	24	2.74	2.89	13.6	16.6
Harris County, TX	9.1	9.1	47	47	d/	d/	d/	d/	8.4	NA	26	26	3.30	3.30	18.2	18.2
Cape Girardeau, MO	7.0	4.3	47	47	73.0	73.0	62.5	62.5	6.3	6.3	15	20	3.60	3.22		13.6
Omaha Area, NB	1.1	9.2	47	46	57.0	70.5	55.0	58.2	3.6	5.7	25	25	2.94	2.79	14.2	14.2
Fargo, ND	d/	d/	45	45	45.8	51.3	49.2	53.5	4.5	4.2	22	22	2.78	2.83	9.5	10.2
Arvada, CO	0.0	0.6	48	48	81.3	89.8	71.6	91.0	1.5	1.2	20	22	3.50	3.87		17.4
Scottsdale, AZ	0.0	1.0	49	45	85.5	73.7	74.2	73.0	0.0	1.1	27	35	2.50	2.14		
TOTAL SAMPLE SAMPLE MEAN	6.4	12.6	48	45	66.5	60.4	73.2	57.8	7.2	3.7	30	29	2.95	2.88	13.9	14.7

a/Non-White as definded in U.S. Census. Orleans Parish not included in aggregation; see text.

b/Under 18/over over 62 population used except: In Cranston the dependent population over 60 was included; and in Palatine and Cranston the population included people over 64 and 65, respectively.

c/Families and Individuals mean income used except: in Jersey Shore median incomes were used; and in Harris County, household income was used

Total community compared here as these data were available when non-hazard data were not such as in U.S. Census Block and Tract

d/Assumed to be the same; see case study appendicies

e/Incidence greater but not quantified due to lack of data

f/Coastal/Seasonal community; not aggregated over 65 and under 18 years of age) was 44 percent of the total.[1] For the floodplains in the sample, the dependent population averaged 48 percent; slightly higher than the 45 percent for the nonhazard areas. These floodplain dependent population percentages exhibit relatively little variation across communities. They ranged from a low of 39 percent in Northampton to a high of 54 percent in Prairie du Chien.

Although there is no complete explanation for the higher dependency ratios in floodplains, part of the reason may be in family size differences. As indicated in Table 13, household size in the sample's aggregate floodplain is slightly higher (2.95) than in its nonhazard area (2.88). The average household size of housing at risk is 3.04, or 5.2 percent greater than that for the total study area. In all communities floodplain household size exceeds nonhazard household size; in 9, the opposite is true. On the whole, the difference is not great enough to infer any significance.

Comparisons of family income were based on data available in the 1970 Census of Population and Housing. Except in a few small study areas outside Standard Metropolitan Statistical Areas (SMSAs), Census Tract data, which include mean family income, were used. From this source it was concluded that the mean income for the entire sample is approximately $14,700, slightly above the $14,000 mean national income of families.[2] This can be explained in part by the weight of the larger urban areas in the sample.

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[1] Bureau of the Census, U. S. Department of Commerce, Current Population Reports, Series P-25, No. 619.

[2] Based on 1975 disposable income from the Office of Business Economics. U.S. Department of Commerce Survey of Current Business Statistics, July 1976.

Family incomes of the floodplain and nonhazard areas could not be compared in detail for all of the case study areas because of a lack of data. The Census Tract boundaries were not always coterminous with floodplain boundaries. In communities where Block Statistics were published, these smaller data units were used to estimate floodplain characteristics. The published Block Statistics, however, did not contain family incomes. In 11 case study areas where such information was available, the data indicate that incomes in the floodplain are 5.4 percent lower than in the nonhazard areas.

As with most examinations of the socio-economic characteristics of a number of communities, this investigation uncovered substantial variation both within and among the study communities. Both high and low income families inhabit the floodplains, as do white and nonwhite families. In some floodplains the dependency ratio is higher than it is in flood-free areas. On balance, however, the differences in the characteristics of the floodplain and nonhazard area populations average out among communities. While some floodplain residents may have difficulty adjusting to floodplain regulations, the data gathered for the 21 case study areas indicate that floodplains are not inhabited disproportionately by disadvantaged families and individuals.

Housing Characteristics

Data on housing types, ownership, vacancy and mean value were assembled for the case study communities. This information is tabulated in Table 13.

Data available from the 1970 Census of Population and Housing and other local sources showed a slightly lower incidence of single family homes in the case study areas than the nation as a whole. This most likely is due to the weight of large urban areas. For the 21 case study areas, there is a higher incidence of single family homes in the floodplain than outside. Also, over 40 percent of the housing stock in these areas was constructed prior to 1940.

Based on the case study communities for which data were available, and where seasonal migration was not a factor (i.e., beach, resort areas), vacancy rates are greater in the floodplain than in the nonhazard areas. For all case study communities the vacancy rate of the floodplain was 7.2 percent. For the nonhazard area it was 3.7 percent. The deterioration of large floodplain neighborhoods relative to nonhazard areas in several case studies partially accounts for this finding.

The incidence of owner-occupied housing in the floodplain of the case study communities is 73.2 percent, well above the national mean of 58.1 percent. For the nonhazard area, the owner-occupied units are approximately the same as the national mean (57.8 percent).

Comparisons of housing values between the floodplain and the nonhazard areas were based on data available in the 1970 Census of Population and Housing. Mean housing values were taken either from Census Tract data or from Block Statistics, which ever unit was more closely coterminous with the floodplain boundaries. The average value of sample housing correlates closely with the national average.

There were significant variations between floodplain and nonhazard area housing values in several communities. The effects of regulations could not be judged from the 1970 data because it reflects conditions prior to the enactment of widespread floodplain regulations. However, the data did show that in riverine communities lower value housing tended to be more prevalent in the floodplains because of the flooding. In 9 communities the floodplain housing values were lower than those in the nonhazard areas. In 2 communities, housing values for the floodplain exceeded the values for nonhazard areas. In 9 communities, no difference was measured. Comparable data were not available for Southampton Town. The variation among the case study communities is shown in Table 13.

Environmental Characteristics

The case study communities encompass a range of physical environments. In 7 case study areas--Westerly, Southampton, Orleans Parish, Harris County, Savannah, Cranston, and Sarasota--there are both coastal and riverine floodplain ecosystems. At locations where coastal and riverine conditions interface, tidal marshes, dunes, lagoons, barrier reefs, and tidal ponds are found. These ecosystems are fragile environments and can be affected significantly by floodplain development. In 13 communities, the floodplain is solely related to riverine conditions. In the remaining community, Toledo, riverine conditions are linked and affected by conditions on Lake Erie.

A variety of riverine floodplain ecosystems are represented in the sample varying with climate, topography, and river stage.

The climatic range falls between the situation of Fargo, North Dakota (cold prairie, low rainfall), Scottsdale, Arizona, (hot desert, low rainfall), and mid-latitude, temperate forest areas such as Prince George's County, Maryland, Representatives of low relief topography are Tulsa, Oklahoma, and Palatine, Illinois, while Arvada, Colorado has a high altitude, mountainous foothill location. Rapid and slow rise flooding, flash flooding, and shallow flooding are represented. The floodplains at Arvada and Palatine typify "young" river systems whereas Orleans Parish, Cape Girardeau, Prairie du Chien, Omaha and Jersey Shore are located in the floodplains of "older" major rivers.

Whatever the geographic situation, the floodplain exhibits an ecology that differs from its adjacent environs. Vegetation and wildlife habitat patterns respond to the physical features of floodplains, e.g., changed (increased) water balance, associated standing water or wetland, inundation by flood, increased nutrient supply, microclimate effects (particularly in the case of incised valleys or dunefields), microtopography, and alluvial deposits.

In areas where the environment naturally supports forest vegetation, the floodplain ecosystem will contain different tree species or a meadow-type vegetation. In drier areas, the floodplain may be the only area to support tree vegetation. Similarly, wildlife habitat patterns exhibit the particulars of the floodplain situation.

Several environmental features of floodplain and coastal hazard areas hold hydrological and ecological values that non-floodplain areas cannot offer. The basic hydrological feature of the floodplain is that it is inundated during floods. The floodplain provides natural flood storage in riverine areas and serves as an area of energy absorbtion of flood forces in coastal hazard areas. When floodplain development occurs a conflict results between natural storage and the new urban uses. Displacement of the storage has the potential to raise flood heights at other locations. Salt marshes can be important buffers against storms.

It should be noted here that floodplain development is not the only factor to increase flood levels; any development within a watershed that renders the ground surface impermeable can result in increased runoff volumes and decreased runoff times both of which produce increased flood discharges and flood levels along the stream system.[1]

In addition to its function as a natural area of stormwater storage, the floodplain has a capacity for assimilating waste materials. The littoral areas of coasts and rivers, particularly wetland areas, have the capacity to operate as a filter for storm water, which has the potential to remove pollutants.[2] Further, in some situations, a hydraulic link exists between the alluvial surficial deposits of the floodplain and subsurface aquifers. In these circumstances naturally filtered storm runoff can be returned to underground water reserves or aquifers. This process is known as groundwater recharge. In the case of Arvada and Palatine, this was particularly significant since the floodplain constituted the primary link between the surface and the aquifer.[3]

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[1] S.G. Walesh and R.M. Videkovich, Urbanization: Hydrologic, Hydraulic and Flood Damage Effects, (West Lafayette, Indiana: 1976).

[2] J.G. Gosselink, E.P. Odum, and R.M. Pope, The Value of the Tidal Marsh, (Baton Rouge, Louisiana: Estuarine Science Department, Louisiana State University, 1973).

[3] John R. Sheaffer and Arthur J. Zeizel, The Water Resource in Northeastern Illinois: Planning Its Use, (Chicago: Northeastern Illinois Planning Commission, 1973).
Wright-McLaughlin Engineers, Urban Drainage: Major Drainageway Planning, (Denver: 1976).

Floodplains, in some of the case study areas, provide for a regionally rare and valued ecology which is a powerful attraction to settlement. In certain areas--Arvada, Harris County, Tulsa, and Fargo among them--the wooded floodplains afford the major areas of tree growth in the communities and thus hold a strong appeal for areas of human habitation and recreation. Wetlands areas, tidal wetlands and ponds, and estuarine areas provide habitats that nurture the origins of fishery food chains. Their value in this capacity has been estimated to be significant in monetary terms.[1]

Although several of the case study communities, Jersey Shore, Prairie du Chien and Sarasota, exhibit a high degree of floodplain development (over 60 percent), development in the floodplain, averaging 17.8 percent, was found to be significantly less than development in the nonhazard area, averaging 29.2 percent (see Table 10, page 92). This indicates that knowledge of the flood hazard, or respect for natural features, has been a factor in the development of flood-prone communities.

Although undeveloped land is the most predominant floodplain land use in the sample communities, the fact that floodplains are surrounded by urban areas means that much of the natural environment has been altered by adjacent development. Further, if estimates that urban floodplains constitute between 3 and 4 percent of the nation's floodplains are valid, then the number of environmental issues is greatly reduced.[2] Environmental issues and effects are most significant where floodplain regulations have a preventive role. This role is important in providing open space and recreational relief to urban areas. The willingness to pay for securing the benefits of open space has been demonstrated in

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[1] Gosselink, _et al_., _Value_.

[2] USDA (1967) 3.2 percent; Corps of Engineers (1973) 3.2 percent; Goddard (ASCE, 1973) 3.4 percent; cited in Goddard, _Evaluation_.

Scottsdale, in which floodplain greenway has been acquired. In DuPage County, Illinois, other research has shown that ecosystem and recreational benefits are valued at more than $26,000 per acre.[1]

Flood Loss Estimates

Flood damage data developed for the case study communities were average annual damages associated with 1975 occupance of the 100-year floodplain. These average annual damages are distributed among the following damage categories: residential, business (separated into commercial and industrial losses where possible), and public, including institutional.

In only one case study (Jersey Shore) was a complete 1975 estimate of average annual losses by category available for the 100-year floodplain from the Corps of Engineers. In the other case study areas, estimates were most often based on general information available from the Corps of Engineers (Corps) and the Soil Conservation Service (SCS). The data required for uniform comparison of case study communities (and extrapolation to national urban losses) were derived from this information in consultation with the Corps or SCS. (Information from external sources was always adjusted to 1975 price levels as a preliminary step.)

Data available from the Corps could be used directly in Prairie du Chien, Wisconsin and Scottsdale, Arizona. In Prairie du Chien, consultation with the Corps was required only to allocate Corps estimates between the island and the mainland. In Scottsdale, it was necessary to allocate losses to the various hazard zones. In the other 19 case study areas, the derivations of flood loss estimates were more complicated and less straightforward.

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[1] Ongoing work by the Corps of Engineers, Chicago District, that is designed to develop and evaluate nonstructural planning alternatives for the DuPage River Basin, Illinois.

In predominantly residential communities, such as Palatine, Prince George's County, Northampton and Sarasota, average annual residential damages were derived according to a procedure developed by Johnson at the Hydrologic Engineering Center.[1] These derivations required information on the type of residential construction in the hazard area, distribution of these stuctures within the floodplain of various frequency storms, and the flood hazard factor. These calculations along with other estimates of total average annual damages were used in the development of a complete set of damage data required for the case study areas. Residential damages as derived from Johnson's method were compared with estimated damage figures to arrive at allocations of flood losses to other categories.

In three case studies, Orleans Parish, Fargo and Wheeling, total average annual damage estimates and the distribution of damages by category in a specific storm event were available. Total damage estimates were adjusted to reflect changes in development between the time of the estimate and existing 1975 conditions. Average annual losses by category were allocated according to their distribution in that known event.

Where average annual damage estimates were available only for an entire river basin, as in Cranston, Omaha, Harris County and Cape Girardeau, it was necessary to derive damages (subtractively) for the study area alone. Such derivations were based on the ratio of study area losses to total losses in an actual storm event or on the ratio of study area floodplain acreage and development to total floodplain and development, depending on available data.

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[1] Hydrologic Engineering Center, Nonstructural.

Where average annual damage estimates were available only for portions of the study area, as in Tulsa, Bergen County, Wayne Township, Toledo, and Arvada, it was necessary to derive damages (additively) for the entire study area. The given estimates were extrapolated to other portions of the study area based on comparison of floodplain acreage and development in the different areas.

As indicated above, flood loss estimates were sometimes adjusted to reflect development changes between the time of estimate or actual flood event and 1975 conditions (Palatine, Fargo, Arvada, Bergen County, Westerly, and Toledo). These adjustments were sometimes based on calculating per unit or per acre damages from the estimate or storm event and extrapolating these to the number of units or acres developed in 1975. (These per unit figures also had to be adjusted for changes in type of structure developed--if these meant increased value--between the time of the estimate and 1975.) If such specific data were not available, the percent of development increase or decrease was estimated and the figures adjusted accordingly. Alternatively, as previously noted, existing residential damages were estimated by Johnson's method and the ratio of existing residential damages to those in the estimate were applied to all categories and the total.

In one community, Southampton Town, New York, damage data were virtually nonexistent. In this case, damage calculations had to be based on comparison with the case study community whose flooding characteristics most nearly approximated those of Southampton Town, i.e., Westerly, Rhode Island. Average annual residential damages were calculated on a percent of structural value derived from the Westerly experience (calculations according to the Johnson method are not applicable in a coastal flooding situation).

Flood damages in each of the case study areas were estimated on an average annual basis as of 1975. Total average annual damages were estimated at 76.6 million (Table 14). These damage estimates do not include damages from catastrophic events to property outside the 100-year floodplain. The two largest communities in terms of land area--Harris County and Orleans Parish (which include 48 percent of the total land area)--suffer 65 percent of the average annual flood losses. The other large study areas in terms of land--Prince George's County, Tulsa, and Omaha--constitute 35 percent of the land area, but experience less than 9 percent of the flood damages.

Residential Losses

Residential flood losses are the most visible and emotion-charged measure of vulnerability. Average annual losses per dwelling unit at risk in the study communities were estimated at $456; the standard deviation was $436. Arvada has the highest damages per residential unit. Well above average dwelling unit damages were found in the hurricane-prone communities of Westerly, Harris and Prince George's Counties. The lowest per unit average annual damages are for Cape Girardeau ($30) and Cranston ($50).

The relative importance of residential flood damages varied widely from case study to case study. Palatine and Sarasota County have residential losses which account for 95 and 78 percent of the average annual damages, respectively. On the other extreme residential damages account for only 3 percent and 10 percent of the total damages in Cape Girardeau and Cranston, respectively. When the entire sample is included, residential damages comprise about half (52 percent) of the total average annual damages.

Business Losses

Damage to commercial and industrial occupants were combined under the heading of business. Total annual business losses for

Table 14: Average Annual Flood Losses in Case Study Communities, by Category, 1975*

CASE STUDY COMMUNITY	Total Damage a/ ($000)	RESIDENTIAL		BUSINESS b/		PUBLIC & T.C.U.	
		Damage ($000)	Damage Per Unit ($)	Damage ($000)	Damage Per Acre ($)	Damage ($000)	Damage Per Acre ($)
Cranston, RI	491	48	50	424	2,330	19	60
Westerly, RI	1,020	610	870	185	2,180	225	4,080
Northampton, MA	214	33	330	136	5,440	45	300
Wayne Township, NJ	2,508	1.129	600	827	2,180	552	1,230
Southampton Town, NY	1,800	3,600	NA		NA	200	NA
Jersey Shore, PA	1,120	350	340	170	12,140	600	9,380
Wheeling, WV	1,564	1,184	230	309	1,030	71	190
Prince Geo. Co., MD	1,338	669	960	268	670	401	200
Savannah, GA	746	346	360	200	710	200	870
Sarasota Co., FL	2,912	2,271	380	175	NA	466	NA
Toledo, OH	1,281	630	115	386	2,240	265	700
Palatine, IL	263	250	360		NA	13	260
Prairie du Chien, WS	150	102	440	40	910	8	90
Orleans Parish, LA	13,310	5,330	160	3,990	1,120	3,990	490
Tulsa, OK	3,166	2,691	550	412	390	63	80
Harris County, TX	36,300	17,500	860	14,500	2,760	4,300	NA
Cape Girardeau, MO	552	16	10	529	690	7	10
Omaha Area, NB	2,100	600	380	600	2,500	900	1,880
Fargo, ND	197	114	140	8	40	75	420
Arvada, CO	3,392	2,248	1,870	1,086	31,940	58	NA
Scottsdale, AZ	149	102	200	16	230	31	280
SAMPLE TOTAL	75,573^c	39,823^c	430	24,261	1,830	12,489	520

* 1975 prices

a/ Does not include agricultural losses (Bergen and San Diego Counties not included)

b/ Commercial/Industrial combined

c/ Losses are for all frequency floods

d/ TCU - Transportation, Communties, Utilities

NA Not available due to lack of land use data the sample were $24.3 million (about 32 percent of total damages). The mean average annual damages per acre were estimated at $1,830 in 1975. This is only about 15 percent of the per acre loss to residences.

Harris County accounts for 60 percent of all the business losses. In terms of damages per acre, the estimates are highest for Arvada ($31,940), Jersey Shore ($12,140), and Northampton ($5,440).

Public Losses

Public losses in terms of flood damages are made up of at least three distinct categories of losses:

1. Losses to public buildings in the 100-year floodplain.
2. Losses to transportation, communications, and utilities (TCU).
3. Losses associated with clean-up, repair, and evacuation.

Estimates of public damages were available where the Corps of Engineers had completed an Urban Study or damage survey (Tulsa, Wheeling, Jersey Shore, Wayne Township, and Orleans Parish). Differences in the definitions of public losses and the lack of hard data resulted in a very wide range of per acre estimates for the case study areas. Communities showing heavy per acre damages are Westerly, Wayne Township, Jersey Shore, Savannah, and Omaha. Public losses account for approximately 16 percent of the sample losses. The mean average annual damage for the sample was $520 per acre.

Relationship to National Estimates

Aggregate average annual damages for the combined case studies were $76.6 million, excluding agricultural losses. Using the Water Resources Council estimates of current average annual losses, $1,215 million for urban areas, the sample was found to represent 6.30 percent of urban flood losses.[1]

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[1] Water Resources Council, Flood Damages, p. 1. Prices adjusted to 1975 levels using Consumers Price Index, all prices.

Economic Effects of Existing Regulations

Floodplain regulations are in place in essentially all of the case study areas, although not for long periods. Nevertheless, an effort was made to identify the economic, social and environmental effects which may have already occurred before attempting to project future effects. Information gathered in some case study communities sheds some light on the limited effects of the regulations. The effects considered include: the loss of property value, cost of flood proofing, and the effects of substantial improvement provisions, and reduction in floodplain housing stock through demolition.

Property Values: Developed and Undeveloped Lands

In the 21 case study areas, detailed information on individual property transactions was not collected. However, information on transactions were solicited from realtors, land developers, bankers and community officials with respect to market property value changes following implementation of floodplain regulations. In the case study areas loss of market value was seen by county assessors and local realtors to be a function of flood events rather than regulations.

The National Association of Realtors recently polled their member boards on the issue of floodplain land values, although the form of the questionnaire could be construed as affecting responses. Of those responding, approximately 35 percent (approximately 12 percent of all the boards) indicated that they believed property values in the 100-year floodplain were affected adversely.[1] These effects reflect, in part, the experience of actual flooding and corroborate the research findings reported by the University of Oregon.[1] One group of those questioned indicated that property values within the floodplain area of their locality had dropped between 5 and 10 percent. Actual flooding or identification of an area as flood prone, such as Harris County Texas, had a greater impact on property values than regulations.

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[1] Statement of Albert E. Abrahams, Staff Vice President, National Association of Realtors, cited in Hearings before the Senate Committee on Banking, Housing and Urban Affairs, Legislative Hearings on S. 1145, 22 April 1977.

The influence of floodplain regulations on market values of floodplain property can be viewed from either the perspective of the effects on developed property or the effects on undeveloped property. With respect to developed property, floodplain regulations exist along with many other regulations and codes which relate to the property. The existing structures are "grandfathered" in (becoming nonconforming uses) and thus do not have to comply with the regulations and codes unless they require substantial improvements. However, the application of substantial improvement regulations to remove nonconforming uses has not been widespread or effective.[2] Thus, the effects on the market values of property would be slight.

The greatest potential for floodplain regulations to affect the market value of property relates to changes in land use, e.g., change from undeveloped to developed land or from single family residential uses to higher intensity uses such as shopping centers or high rise apartment buildings. If such desired changes are affected by floodplain regulations, anticipated windfall profits associated with such transactions may not be realized. However, it is important to note that windfall profits associated with land speculation frequently are not realized independent of any regulations.[3] Thus windfall anticipations often are not realistic.

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[1] Warnick, Growth Rates.

[2] Sheaffer & Roland, Inc., Substantial Improvement.

[3] Statement of Mr. Clyde Kautz, President, Kautz and Company Realtors, Glen Ellyn, Illinois.

With respect to the tax rolls, undeveloped property is generally assessed at low rates. Thus, there is little relationship between the assessed rate, the actual market value, and the owner's speculative or anticipated windfall value.

In coastal and some arid area case studies, it was observed that floodplain properties showed strong enhancement value due to local cultural and aesthetic values. This observation is supported by the findings of Kunreuther et al.[1] In their sample of 44 communities, the rate by which the value of housing increased was greater in high risk hazard areas (5.23 percent) than in low risk hazard areas (4.58 percent). This supports a hypothesis that in arid areas, coastal areas, and areas without topographical relief, property values vary directly with proximity to vistas of water and nearness to vegetated zones. It also deviates from the findings of Warnick which showed that land values in Clakemas County, Oregon floodplains continued to appreciate, albeit at a rate lower than in nonhazard areas.[2]

In Tulsa, Oklahoma, flood damages are recognized as a loss of value by the City Assessor. Following a flood event, a temporary (one year) tax rate reduction is available to owners of flooded properties. In Tulsa's higher income residential areas, however, these tax benefits sometimes are turned down because it is feared that a flood record would lower a property's value.

In Wayne Township, New Jersey, realtors and bankers stated that, in their experience, there was no difference in value between comparable floodplain and nonfloodplain properties.

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[1] Kunreuther et al., Limited Knowledge, Table 9.1.

[2] Warnick, Growth Rates.

In coastal communities (Westerly, Southampton, and Sarasota), land values were not depressed in the designated hazard area. In all of those communities, land values in the floodplain were high, reflecting the premium placed on oceanfront property. Neither floodplain regulations nor past flood events appeared to have lowered the value.

In Palatine, Illinois, increased land value occurred as a result of management of open space in regulated floodplains. Residential properties in the nonhazard fringes of floodplains benefit from the aesthetics of managed river and lakefront open space. Values were found to have ranged from $125 per front foot for unmanaged floodplain open space to $300 per front foot for managed floodplain open space. Officials in Prince George's County also recognized this effect.

Detailed information on individual property transactions was developed in a research effort by the University of Oregon. This research compared the assessed value of residential land parcels inside and outside the regulated flood hazard areas.[1] Land parcels on each side of the flood hazard boundary line on two sites on the Willamette River were compared for a twenty-year period that spanned the years before and after the application of floodplain regulations. It was found that before regulations were imposed, the land parcels in the flood hazard area appreciated at a more rapid rate than did those outside the flood hazard area. However, after regulations were imposed, this trend appeared to reverse and land in the flood hazard area appreciated at a slower rate than land outside the flood hazard area.

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[1] Warnick, Growth Rates.

The same research also found that lands in the floodplain had experienced changes in values before floodplain regulations were imposed. Those earlier value changes had occurred as a result of actual flooding events where damage to property had depressed values. The lessened rate of appreciation resulting from flood events was greater than that resulting from floodplain regulations. Flood events not only reduced the rate of appreciation but actually caused a depreciation in the value of several parcels. Regulations were not seen to have had such a drastic effect.

In order to supplement these tentative and sparse findings with more detailed empirical data gathered expressly to examine the effect of regulations on property values, information on hazard area and nonhazard area property values and transactions was collected and analyzed in a special case study in Bergen County, New Jersey. Many claims of loss of value had been made and approximately 850 homeowners had filed for reduced property assessments.

Sale prices and asking prices are compared in Table 15. Also compared are sale prices and appraised value. The limited data on these points shows that sellers of floodplain property do not fully achieve what they anticipated; the average sale price was 5 percent less the asking price. When the sale price was compared with a professional appraisal, however, the average seller received a sales price exceeding the appraised value of his home. This empirical evidence collected indicated that property values in the 100-year floodplain were not affected adversely by regulations.

Table 15: Relationship between Sale Price and Asked Price and Sale Price and Appraised Value for Existing Property in Regulated Floodplains of Bergen County, New Jersey

Sale Price vs. Asked Price	
Number of Transactions	18
Selling Price Below Asking Price--	
Number	14
Average Reduction (Mean)	$ 4,500
Percent of Asking Price	5
Average Selling Price (Mean)	$85,200
Sale Price vs. Appraised Value	
Number of Transactions	6
Selling Price Above Appraised Value	5
Selling Price at Appraised Value	1
Average Increase of Selling Price Over Appraisal	$ 1,500
Average Selling Price (Mean)	$82,200

Source: Property listings and sales records collected by field team, September 1977.

The data gathered for Bergen indicated there was no significant inhibition of the marketability of homes in the flood hazard areas. Final selling prices of flood hazard and nonhazard properties were comparable in terms of their sales index ratio (assessed value to sale price). The sales index ratio based on 174 transactions analyzed was essentially the same for both floodplain and nonhazard property. This is significant, for in New Jersey, if the ratio drops below 0.7 a reassessment of property must be undertaken. Also, the information gathered in the field suggested the sale of floodplain properties did not appear to be impeded by regulations. The transactions studied indicated that the properties subject to regulations have increased in value at rates equal to, and sometimes exceeding, those for other properties in the community. Appendix C presents the details on these transactions which took place during a period of intense debate over the potential adverse effect of floodplain regulations.

Asking prices were reduced by sellers in both the regulated floodplain and the nonhazard area. The reductions appear to be the same--about 6 percent of original asking price in both groups (see Table 16).

Based on the detailed evaluation in Bergen County, it appears that floodplain regulations per se did not produce significant effects on property values. Also, the sale of floodplain properties did not appear to be impeded. And, persons who claimed that regulations would affect property values were found to be unaware of the range of development options--flood proofing alternatives--open to them under the floodplain regulations.

Flood Proofing Costs

A special study was conducted as a supplement to this research project to investigate the costs involved with flood

Table 16: Comparison of the Marketability of Housing in the Floodplain and Nonhazard Areas of Bergen County, New Jersey

	Hazard Area Properties	Nonhazard Area Properties
Asking Prices (Northwest Bergen County)		
Number of Listings	24	210
Reductions--		
Number	7 (29%)	54 (26%)
Average Value (Mean)	$ 4,400	$ 6,400
Percent of Original Asking Price	6	6
Original Asking Price	$71,000	$110,800

Source: Property listings and sales records collected by field team, September 1977.

proofing a proposed commercial building at Jersey Shore, Pennsylvania.[1] The costs of constructing a building at grade were compared with constructing the same building using three flood proofing techniques: 1) raised on fill (7 feet) to one foot above the 100-year flood: 2) raised on fill (4 feet) and equipped with watertight closures (3 feet) that extend to one foot above the 100-year flood; and 3) raised on columns (12 feet) to 6 feet above the 100-year flood.

Flood proofing increased the costs of construction from 6 to 16 percent depending on the approach used. The cost increases were compared in Table 17, first to the benefits of reduced flood insurance premiums and second, to the benefits of reduced flood losses including business interruption losses. Flood insurance premiums at actuarial rates were reduced by from 94 to 98 percent and average annual flood losses were reduced by from 85 to 92 percent.

The present value of these costs and benefits were then calculated and benefit/cost ratios were derived (see Table 17). For flood proofing costs compared with reduced insurance premiums the benefit/cost ratios ranged from 5.96 to 2.31. For flood proofing costs compared with reduced flood losses the benefit/cost ratios ranged from 3.46 to 1.39. The main conclusion of the study was that flood proofing of a new commercial building at Jersey Shore, Pennsylvania, in a manner consistent with minimum NFIP regulations is economically justified in terms of reduced insurance premiums, reduced flood losses and reduced disruption.

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[1] Sheaffer & Roland, Inc, Feasibility.

Table 17: Benefit/Cost Ratios of Alternative Flood Proofing Solutions for a Small Commercial Building[a]

	ALTERNATIVE FLOOD PROOFING DESIGNS			
	Wet Flood Proofing[b]	Raised On Fill[c]	Partially Raised On Fill With Watertight Closures[d]	Raised On Columns[e]
Cost of Flood Proofing per Square Foot	$2.09	$1.60	$3.97	$3.91
Benefit/Cost Ratios[f]				
1. Reduction in Annual Insurance Premiums ÷ Cost of Flood Proofing	0	5.96	2.31	2.48
2. Reduction in Average Flood Losses ÷ Cost of Flood Proofing	0.25	3.46	1.39	1.53

[a] Based on a multi-store commercial building of 22,500 sq.ft. proposed in Jersey Shore, PA

[b] Allows entry of flood waters to equalize hydrostatic pressure on both sides of structural walls; does not meet minimum National Flood Insurance Program regulations and can not receive a reduction in flood insurance rates.

[c] Raised on fill 7 ft. to one foot above the 100-year flood

[d] Raised on fill 4 ft., equipped with 3 ft. of watertight enclosures

[e] Raised on columns 12 ft. (6 ft. above 100-year flood) to accomodate parking

[f] Compared to the basic building without flood proofing

Source: Sheaffer & Roland, Inc., *Economic Feasibility of Flood Proofing: An Analysis of a Small Commercial Building*; prepared for the Office of Policy Development and Research, Department of Housing and Urban Development (1977).

Information was also gathered on the costs of flood proofing in the case study areas. In Fargo, North Dakota it was found that the Fargo-Moorhead Home Builder's Association had recent home construction experience involving flood proofing techniques. Based on data provided by the Association, it was shown that the average cost of flood proofing basements ranges from $350 to $650 and the cost for elevating the housing units on fill or columns ranged from $4,000 to $6,000 for new housing units selling from $36,000 to $75,000 (8 to 11 percent). This shows that the cost of flood proofing a residential structure adds a comparable percentage to the construction cost as was found with the Jersey Shore commercial structure. In the Fargo area, flood proofing generally results in a increased construction cost equal to about 10 percent.

In Wayne Township, New Jersey, existing residences are being raised above the base flood elevations at a cost ranging from $3,000 to $5,000 per building. This is less than 10 percent of the market value of the structures and corresponds to Johnson's finding that raising an existing home 3 feet imposes a cost equal to 2.1 percent of the structure's value.[1]

In several case study areas that experience frequent shallow flooding (Cranston, Toledo, Palatine, Scottsdale, and Harris County) flood proofing techniques are incorporated into normal building procedures. Costs of floodproofing in such instances generally average from 2 to 5 percent of construction costs.

Information gathered in the case studies suggests that the cost of flood proofing does not weaken the marketability of housing units. In Orleans Parish, historically buildings have been raised on columns for protection from the 40 year flood level. Over one half of the City's housing units are provided partial protection in this manner. In coastal areas such as Sarasota, Florida and Westerly, Rhode Island, seasonal beach homes as well as year round housing units and high-rise buildings are elevated. In Wheeling, West Virginia, new housing units on Wheeling Island are being flooded proofed without being required by local regulations.

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[1] Hydrologic Engineering Center, *Nonstructural*, p. 24.

Empirical evidence from the case studies and the special study of the economic feasibility of flood proofing a commercial building in Jersey Shore shows that the cost of raising a new building above the 100-year flood stage is a relatively small 10 percent. Research published subsequent to the case study work indicates that the extra cost of elevating a new home 3 feet or less is on the order of 0.5 percent of structural value.[1]

Based on the information gathered a 10 percent increase in construction costs was assumed for the economic projections in Chapter V.

Economic Effects on the Community

Tax base foregone due to regulations was not found to be a measurable loss in any of the case studies. Floodplain regulations in the case study areas did not cause a community to lose its development potential. Community leaders in all but two case studies (Jersey Shore and Cape Girardeau) tended to discount the influence of floodplain regulations in their assessments of local economic development potential. As evidence they cited the availability of abundant comparable alternative sites for development within the nonhazard portion of the study areas (about 70.6 percent of the nonhazard area is now undeveloped).

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[1] Ibid., p. 65.

Economic Effects on Existing Structures

In terms of existing structures, floodplain regulations, through their substantial improvement requirements, were not found to affect property values. Regulations of the National Flood Insurance Program (NFIP) currently define a substantial improvement to an existing structure as any repair, reconstruction, alteration, or rehabilitation whose value exceeds 50 percent of the market value of the structure prior to the improvement. Upon reaching the 50 percent threshold, the improvement must comply with NFIP regulations (e.g., flood proofing or elevating). In addition, flood insurance must then be purchased at actuarial rates to cover the amount of the mortgage or loan. The reduce risk achieved through flood proofing can lower insurance rates to a point where the savings in premiums offsets the flood proofing costs.

A separate study for the FIA, the findings of which are summarized in the following discussion, was conducted to estimate the number of residential and nonresidential structures which meet the substantial improvement definition.[1] The 126,000 dwelling units that are substantially improved each year represent only 0.2 percent of the 72,600,000 occupied dwelling units reported by the Bureau of Census in 1975.[2] The 13,600 dwelling units within the hazard area comprise only 0.02 percent of the occupied housing units. The 4,600 nonresidential structures in the floodplain represent only 0.1 percent of the 4,110,000 establishments reported by the Bureau of the Census in 1974.[3] Thus, the number of residential and nonresidential structures in the nation's 100-year floodplains that are improved to exceed the 50 percent of market value definition of substantial improvement activity annually is relatively small.

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[1] Sheaffer & Roland, Inc., Substantial Improvement.

[2] Bureau of the Census, Department of Commerce, 1975 Annual Survey of Housing.

[3] Bureau of the Census, Department of Commerce, County Business Patterns, 1974.

Discussions with planners and zoning and building officials indicate that implementation of the substantial improvement regulation was virtually nonexistant. The record of minimal enforcement was due in part to political and financial constraints at the local level. However, even if enforcement were 100 percent effective, it is unlikely that the regulation would clear floodplains of urban development within a reasonable amount of time because of the small number of structures affected annually.

Demolitions

Another way to affect existing floodplain structures is through demolition. This is a necessary first step in any programmed land use change. The demolition of structures is common in urban areas. The number of dwelling units authorized for demolition in the nation over the seven year period 1969 through 1975 averaged 132,000, as reported by the Census.[1] These demolitions represent the number of units that are programmatically removed from the nation's housing stock (e.g., private changes in land use, urban renewal, planned projects, and community development). In the case study communities, there were an average of 2,400 dwelling units authorized for demolition annually for the five year period 1971 through 1975. (This excludes Harris County, Texas for which no data were available on the county level for unincorporated places.) Dwelling units authorized for demolition in case study communities represent 3.6 percent of the annual national average.

A comparison of residential structures which would be candidates for substantial improvements with structures that are slated for demolition shows an interesting relationship. There are 13,600 candidate dwelling units in the floodplain for substantial improvements and 132,000 dwelling units authorized for demolition annually. Therefore, this means that demolition or the natural succession of land use changes as it is currently programmed is the major tool to bring about adjustments in floodplain occupance. If all candidate housing units for substantial improvement were to be purchased and razed, annual average appropriations of $370 million would be required.

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[1] Bureau of the Census, Department of Commerce, Construction Reports: Housing Units Authorized for Demolition in Permit Issuing Places, 1971-1975.

Summary of Case Study Conditions

The total floodplain area in the case studies was 19.7 percent of the total area of the sample. The sample's floodplains are less intensively developed than the nonhazard areas. Development was 17.8 percent in the floodplain and 29.4 outside it. In every developed category of land use but industry, the intensit of land use in the floodplain is significantly lower than in the nonhazard area. While residential uses occupied 8.6 percent of the floodplain's area, or only 1.7 percent of the total study area, it contained 13.5 percent of all housing units. Some 53.7 percent of these, or 7.2 percent of all housing, was actually at risk from the 100-year flood in 1975. Density was greater in the floodplain, 5.7 dwellings per acre compared to 4.8 outside the floodplain.

Occupants of the flood hazard area exhibited slightly higher dependency characteristics and lower family income traits than their nonhazard area counterparts. On the other hand, the concentration of renters and minority populations was lower in the floodplain.

Compared to the nonhazard areas, the vacancy rate was nearl double in the floodplain due to the generally higher presence of older and more substandard housing. Where housing value data were obtainable it was found that values were in fact lower in riverine floodplains than in the nonhazard areas of riverine communities. In coastal communities that are resort oriented, the opposite was found.

Of the $76.6 million average annual urban flood losses estimated for the case study areas, residential losses accounted for 52 percent, commercial and industrial losses accounted for 32 percent, and public uses including urban support facilities accounted for the remaining 16 percent.

Property values were found to be affected more by flooding than application of regulations. Compliance with floodplain regulations did not appear to be a deterrent to development in any of the case studies. This finding was confirmed by the in-depth evaluation of property values undertaken in Bergen County, New Jersey.

Flood proofing increased commercial construction costs by 6 to 16 percent. This did not reduce the viability of a proposed structure because of the reduction in flood losses and insurance costs. Field work and other information indicate that residential flood proofing, whether retrofit or new construction, is often economically viable.

Existing structures are not affected by substantial improvement regulations. Programmed changes in land use through demolition of existing structures affects many more structures--approximately 10 times the number that could be affected by substantial improvements.

The 21 case study areas represent a large proportion of the NFIP flood prone community characteristics. They represent the following:

- 2.21 percent of the estimated flood hazard area dwelling units;
- 1.99 percent of the estimated population of all such flood prone communities;
- 1.37 percent of the delineated floodplains; and
- in terms of average annual flood losses, the case studies account for 6.30 percent of the nation's average annual flood losses as estimated by the Water Resources Council.

With this information on existing conditions in the case study communities as a base, projections of the future effects of regulations can be made. This is done in Chapter V.

CHAPTER V

ASSESSMENT OF THE EFFECTS OF FLOODPLAIN REGULATION

The current economic, social, and environmental conditions in the case study communities form a base from which future short term (1980) and longer term (1990) effects of floodplain regulations were estimated. To assess the economic, social, and environmental effects of floodplain regulations, it was necessary to project future populations and land uses which stem from different regulatory scenarios and to measure the differences among them.

The three regulatory scenarios applied to the selected case studies were presented in Chapter III. They vary with respect to degree of regulation over land use and building practices and thus will have varying effects on floodplain occupance. The differences in occupance among the scenarios were analyzed to gain insight into several economic, social, and environmental effects.

Projections of occupance characteristics for the case study areas stemmed from their own planning and economic forecasts. These forecasts were modified when it was observed that they were not compatible with either national economic, demographic and housing trends or trends within the case study areas themselves.

In all case studies, the effects of land use regulations were quantified to the degree practicable. (The detailed projection procedure was described in Chapter III). Throughout the case study analysis, monetary effects are reported on an average annual basis in constant 1975 dollars.

Future Occupance

Estimates of future occupance were made for each case study for the alternative regulatory scenarios. The aggregated differences between housing, population and land use were gleaned from these estimates. A brief discussion of the variations found among the scenarios is presented in the following sections.

Housing

The summary of housing projections for the aggregated case study communities is presented in Table 18. The projections show the distribution of housing units between the hazard area and the nonhazard area that is achieved by the three regulatory scenarios. Within the hazard area, a distinction was made to show which housing units were at risk, i.e., below the level of the 100-year flood elevation. The number of new units and number of units retired or removed was derived from an analysis of local data and trends. The regional setting for these data was derived from the areawide economic forecasts made by the Bureau of Economic Analysis, U.S. Department of Commerce.

Without floodplain regulations (Scenario I), the number of housing units at risk would increase from the base of 87,400 to 98,400 in 1980 and 116,500 in 1990. This would constitute a 33 percent increase in housing units at risk over a 15-year period.

With moderate regulations (Scenario II), new construction is allowed in most of the floodplain as long as it is raised above the 100-year flood elevation. Thus, the number of housing units in the floodplain would increase. However, the housing units at risk would actually decline by 4.7 percent because new structures would be elevated and some existing units replaced or retired.

In Scenario III, regulations prohibit the construction of new housing units in the floodplain and initiate corrective measures. The number of housing units in the floodplain would

Table 18: Projected Housing By Scenario: 1975-1990[a]

	1975	1980			1990		
	Base	I	II	III	I	II	III
NUMBER OF UNITS							
Total Study Area	1,207,200	1,346,900	1,346,900	1,341,600	1,583,300	1,582,100	1,565,100
Percent Change		11.6	11.6	11.1	31.2	31.1	29.6
Flood Hazard Area	162,800	184,100	176,300	160,500	219,700	197,900	156,700
Percent Change		13.1	8.3	-1.4	35.0	21.6	-3.7
At-Risk[b]	87,400	98,400	85,700	85,800	116,500	83,300	83,600
Percent Change		12.9	-1.9	-1.8	33.3	-4.7	-4.3
Non-Hazard Area	1,044,400	1,162,800	1,170,600	1,181,100	1,363,600	1,384,200	1,408,400
Percent Change		11.3	12.1	13.1	30.6	32.5	34.9
NEW UNITS							
Total Study Area		144,400	144,400	140,900	294,400	249,400	237,500
Flood Hazard Area		23,600	15,800	0	39,600	25,600	0
At-Risk[b]		12,600	0	0	20,500	0	0
Non-Hazard Area		121,700	129,400	139,800	213,200	232,100	239,600
RETIRED UNITS							
Total Study Area		8,900	8,900	8,800	16,300	16,300	16,100
Flood Hazard Area		2,300	2,400	2,300	4,000	4,000	3,800
At-Risk[b]		1,600	1,700	1,600	2,400	2,400	2,200
Non-Hazard Area		6,600	6,500	6,500	12,000	12,200	12,200

[a]- Housing data for 21 case studies. (Bergen and San Diego Counties excluded due to lack of comparable data.)

[b] At-Risk = subject to 100 year flood elevation (at grade).

show a decline of 3.7 percent by 1990. Also, there would be a decrease in the number of housing units at risk. The rate of decrease would be slightly slower than what was projected for Scenario II. The reason for this is the inability to change among the various urban land uses because of the prohibition of new structures. Thus, existing structures are not removed unless they are candidates for substantial improvement regulations. In this sense, Scenario III has some effect on the natural progression of land use change which is present in urban areas.

The number of housing units actually situated on the floodplain increases under Scenario II. This reflects the number of new houses that would be constructed in the floodplain but elevated to the level of the 100-year flood. By 1990, the number of new housing units in the floodplain was projected to increase by 35,100 units. Under Scenario III, no new units could be constructed in the floodplain.

The total number of housing units for the aggregate case study communities in 1980 under Scenario I and Scenario II would be equal. The 15,800 housing units that are not located in the floodplain in Scenario II would be accommodated in the nonhazard portions of the study areas. In Scenario III, it was estimated that there would be a shift of 5,300 housing units from the case study areas. These units would, however, remain within their respective economic regions. This trend was projected to continue for Scenario III so that by 1990, there would be a projected 5 percent shift of new housing units from the case study areas to other areas within the economic region.

Essentially the same number of housing units would be at risk within the 100-year floodplain under both Scenario II and Scenario III. As previously stated this reflects both the ability to replace existing structures with flood proofed structures under Scenario II and the interference with the natural succession of housing that would occur under Scenario III.

Population

Population projections closely mirror housing projections. In this study, the trend toward reduced household size was projected to proceed uniformly in both the hazard and nonhazard areas. This trend has a moderating effect on changes in the hazard area population. Table 19 presents a summary of population projections for the aggregate case studies under the regulatory scenarios.

In Scenario I, the floodplain population (as well as housing) is projected to grow at a slightly higher rate than in the nonhazard area. This increase is due, in part, to demand for the aesthetic benefits of coastal proximity (Westerly, Southampton, Sarasota and Toledo) and riverfront access in arid areas or areas without much topographic relief (Savannah, Tulsa, Fargo, Palatine and Arvada). Another factor is the large quantity of available undeveloped land in the floodplain. Thus, the 1990 population of the hazard area would increase by 28.9 percent and the population at risk would increase by 33.3 percent. Under Scenario II the 1990 floodplain population would increase by 17.1 percent. However, since new housing conforms to regulations, and some older housing is retired, the population at risk would decrease by 6.9 percent. The stringent regulations of Scenario III would result in a drop in both the number of floodplain occupants (5.6 percent) and in those at risk (6.6 percent).

The most significant observation regarding the two regulatory scenarios is that they reduce the population at risk with about equal effectiveness. However, moderate regulations would allow a small increase in the number of floodplain occupants; while losses due to low probability events would be very low, disruption, in terms of access problems, would remain significant. From a social perspective, Scenario III achieves a total reduction in the population that would be vulnerable to the effects of flooding.

Table 19: Projected Population By Scenario: 1975-1990

	1975 Base	1980			1990		
		I	II	III	I	II	III
Total Study Area	3,489,200	3,857,100	3,857,300	3,840,900	4,476,700	4,476,600	4,424,600
Percent Change		10.5	10.5	10.5	28.3	28.3	26.8
Flood Hazard Area	480,500	537,200	513,100	470,200	619,300	562,900	453,700
Percent Change		11.8	6.8	-2.1	28.9	17.1	-5.6
At-Risk*	265,500	301,100	261,000	261,100	354,000	247,100	247,900
Percent Change		13.4	-1.7	-1.7	33.3	-6.9	-6.6
Non-Hazard Area	3,016,600	3,319,900	3,344,200	3,370,700	3,857,400	3,913,700	3,970,900
Percent Change		10.1	10.9	11.7	27.9	29.7	31.6

Bergen and San Diego Counties not included

*At-Risk = subject to 100 year flood elevation (at grade)

The population growth diverted outside the floodplain by Scenario II would be retained within the case study area boundaries because there is sufficient available land. For Scenario III, some population would be diverted from the study areas but would be retained within the respective economic regions. This effect compares to that projected for housing diversion in the previous section.

Land Use

Floodplain regulations produce a pronounced shift of development from the floodplain to nonhazard areas that varies directly with regulatory stringency (see Table 20). Scenario II, moderate regulations, would result in the diversion of 33 percent of the development expected to occur by 1990 under the unregulated scenario to the nonhazard area. This would be primarily a result of decisions by developers. The remainder would be placed in the floodplain but would not be at risk because it would be placed in the floodplain level of the 100-year flood. Scenario III regulations would reduce the acreage of developed land in the floodplain. Some land currently developed would be converted back to open-space uses through the removal of structures requiring substantial improvement. Under Scenario III, the shift of future development from the urban region would be total.

Table 20 shows that the undeveloped amount of the hazard area would increase from 273,800 acres (1975) to 274,800 (1990) under Scenario III. This would constitute a net gain in floodplain open space of approximately 0.4 percent. In contrast, an additional 14,200 acres of floodplain open space would be developed in Scenario II by 1990 (a 5.2 percent reduction). In Scenario I, an additional 22,100 floodplain acres would be converted from open space to developed use (a loss of 8.1 percent).

Table 20: Projected Change in Developed and Undeveloped Land, By Scenario: 1975-1990

	1975	1980			1990		
		I	II	III	I	II	III
DEVELOPED LAND							
Study Area							
Acres	458,900	511,300	511,400	508,000	649,600	649,500	641,700
Percent of Study Area	27.1	30.2	30.2	30.0	38.4	38.4	37.9
Percent Change[a]		11.4	11.4	10.7	41.6	41.6	39.8
Flood Hazard Area							
Acres	59,300	67,900	64,500	58.900	81,400	73,500	58,300
Percent of Flood Hazard Area	17.8	20.4	19.4	17.7	24.4	22.1	17.5
Percent Change[a]		14.5	8.8	-0.7	37.2	24.0	-1.6
Non-Hazard Area							
Acres	399,600	443,400	446,900	449,100	568,200	576,000	583,400
Percent of Non-Hazard Area	29.4	32.6	32.9	33.1	41.8	42.4	43.0
Percent Change[a]		11.0	11.8	12.4	42.2	44.1	46.0
UNDEVELOPED LAND							
Study Area							
Acres	1,232,300	1,179,900	1,179,900	1,183,200	1,041,600	1,041,700	1,049,500
Percent of Study Area	72.9	69.8	69.8	70.0	61.6	61.6	62.1
Percent Change[a]		-4.3	-4.3	-4.0	-15.5	-15.5	-14.8
Flood Hazard Area							
Acres	273,800	265,200	268,600	274,200	251,700	259,600	274,800
Percent of Flood Hazard Area	82.2	79.6	80.6	82.3	75.6	77.9	82.5
Percent Change[a]		-3.1	-1.9	0.1	-8.1	-5.2	0.4
Non-Hazard Area							
Acres	958,500	914,700	911,200	909,000	789,900	782,100	774,700
Percent of Non-Hazard Area	70.6	67.4	67.1	66.9	58.2	57.6	57.0
Percent Change[a]		-4.5	-4.9	-5.2	-17.6	-18.4	-19.2

Economic Effects of Projected Occupance

The effects of floodplain regulations are most evident in the change in land use and building practices in the floodplain itself. The major economic consequences of land use changes brought about by floodplain regulations are changes in the level of flood losses and in economic development potential.

Flood Losses

Without regulation of the hazard area (Scenario I), flood losses were projected to increase at an accelerating rate (see Table 21). Average annual losses by 1980 would be approximately 29 percent higher than in 1975. By 1990, flood losses were projected to increase by about 71 percent over 1975 estimates. Residential land uses would suffer the largest increase in losses.

The projections indicate that moderate regulations would be effective in reducing the loss profile of new development. Under moderate regulations, losses would be much lower in any given year than without regulations. Moreover, the expected losses of Scenario I and II would diverge widely over time. In 1980 aggregate sample losses under the moderate regulations of Scenario II would be some 19 percent lower than the unregulated approach of Scenario I; the differential by 1990 would be 35 percent.

If further development and substantial improvement were completely prohibited (Scenario III), there would be absolute decrease in flood losses. By 1980, a slight reduction from 1975 levels would occur (0.2 percent); by 1990 it would be 0.6 percent. Given the confidence limits of the data, one could argue that these reductions might vary in either direction. However, the internal logic of the scenario dictates that losses would drop under Scenario III since housing values are held constant and the

Table 21: Projected Average Annual Flood Losses by Community Sector, By Scenario: 1975-1990

COMMUNITY SECTOR	1975	1980			1990		
	Base	I	II	III	I	II	III
Residential	$ 39,823	$ 53,785	$ 40,810	$ 39,543	$ 73,823	$ 43,083	$ 39,102
Percent Change		35.1	2.5	-0.7	85.4	8.2	-1.8
Business	24,261	29,482	24,992	24,366	38,388	26,147	24,425
Percent Change		21.5	3.0	0.4	58.2	7.8	0.7
Public	12,489	15,295	13,573	12,527	18,833	15,530	12,561
Percent Change		22.5	8.7	0.3	50.8	24.3	-0.6
TOTAL	$ 76,573	$ 98,561	$ 79,374	$ 76,439	$ 131,042	$ 84,560	$ 76,088
PERCENT CHANGE		28.7	3.7	-0.2	71.1	10.4	-0.6

(1975 Price Level - in thousands)

Bergen and San Diego Counties not included due to lack of comparable data.

housing stock on the floodplain would be reduced. This reduction results from the gradual corrective actions which would be achieved through the removal of structures requiring substantial improvements. The process of removal is slow. A research effort concluded that perfect enforcement of substantial improvement regulations would affect only 3 percent of the existing floodplain housing units over a ten year period.[1]

Estimates of future flood losses were categorized under the headings of residential, business, and public for each scenario. Residential damage projections were based on estimates of 1975 flood losses that were adjusted to reflect projected changes in residential floodplain occupance. Flood losses to the new development that would take place under Scenario I were assumed to be the same percentage of the property value as the 1975 flood losses were. Also increases in the value of residential construction were incorporated in the analysis.

In Chapter III, the average annual flood loss per housing unit in the case study communities was estimated to be $430 (see Table 14). When this loss is compared to the average value of a housing unit excluding land ($22,000 in 1975), it was determined that flood losses constitute about 2 percent of the value of the housing unit. By the same reasoning, new housing units conforming to moderate regulations (raised to the level of the 100-year flood) were estimated to be subjected to average annual losses representing 0.28 percent of structural value. This loss is due, in part, to the residual losses from floods greater than the 100-year event. Thus, average annual losses to a residence which is elevated to the level of the 100-year flood would be only 14 percent of the losses that would be experienced by a residence that is not raised.

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[1] Sheaffer & Roland, Substantial Improvement, p. 56.

Over time, as existing floodplain structures are razed and replaced by more expensive and elevated structures, the differential in loss per replaced unit between Scenario I and Scenario II will be less than 86 percent. For example, a $30,000 home experiencing $600 in average annual losses (2 percent) is replaced by a $50,000 home experiencing $140 in average annual losses (0.28 percent). In such a situation, the reduction in losses would amount to 77 percent. The process of replacement on a lot-by-lot basis would result in such decreased losses per lot until all residences at risk have been replaced. In Scenario II, the average annual flood loss suffered per residential unit was assumed to be 0.28 percent of the structural value of the new development.

A portion of this new construction would take place on lots previously unoccupied. These "original" conforming structures would sustain average annual losses at the rate of 0.28 percent of structural value--the same as for replacement structures. Referring to Table 18 which indicates that retirements are about 20 percent of new units constructed in the floodplain, and assuming that all retired units are replaced by conforming units of greater value, it is possible to see that losses under Scenario II would continue to increase, but at a lesser rate than under Scenario I.

Scenario II would be effective in limiting the increase in expected average annual residential flood losses. By 1990, average annual losses would increase by only 8.2 percent over 1975 levels under Scenario II compared to an increase of 85.4 percent in Scenario I. Scenario III would reduce absolutely average annual losses by 1.8 percent by 1990. Moderate regulations would slow the rate of increase in residential flood losses, while Scenario III would stop and ultimately reverse the nation's trend of increasing flood losses.

Projections of business flood losses were based on estimates of 1975 losses, adjusted for projected changes in commercial and industrial floodplain occupance. The flood losses for new construction under Scenario I were based on 1975 average per acre damage estimates in each case study. The 1975 per acre losses were adjusted to account for increases in construction costs. In most cases, an escalation factor of 25 percent was applied.

With respect to Scenario II, new construction would be flood proofed to or above the level of the 100-year flood. In the absence of better data, the same flood loss factor that was developed for residential structures in each community was applied to the new flood proofed commercial and industrial development. Reductions associated with retirements of businesses from the hazard area were based on average per acre business damages in 1975. Where residential flood loss projections were based on current Corps of Engineers estimates which incorporated inflation factors for future watershed development, similar adjustments were applied to projections of business losses.

A 57.9 percent increase in 1990 average annual business flood losses is projected under Scenario I. The moderate regulations under Scenario II would reduce this increase to 7.5 percent. Stringent regulations, Scenario III, would allow no new construction. Thus, under Scenario III the 1990 level of flood losses would increase only slightly above the 1975 level.

Projections of public flood losses were also based on per acre estimates of 1975 losses. In some cases, where substantial increases in occupance of the hazard area and commensurate increases in urban infrastructure were projected, losses were projected to increase commensurately (Scenario I). In Scenario II, where new public buildings would be elevated to or above the level of the 100-year flood, losses would continue to increase, reflecting residual losses to the structures and losses to the urban infrastructure which would serve development in both the floodplain and the non-hazard area.

With no regulations (Scenario I) the 1990 average annual public losses would increase by 51 percent. The moderate regulations of Scenario II would result in an increase in average annual public flood losses of approximately 24 percent. In Scenario III the slight increase in estimated annual losses results from the gradual replacement of the existing urban infrastructure that services the current floodplain development. The replacement would be more costly.

The rate of retirement of buildings that are to be substantially improved would not be affected by Scenario I. Neither would it be affected appreciably under Scenario II. With respect to Scenario III, there would be no repair of substantially damaged property nor would existing property be substantially improved. Therefore, a decline in occupance would take place over time. This decline would be gradual, taking 50 years to remove 15 percent of the existing housing units from the floodplain if sole reliance was placed on effective enforcement of substantial improvement regulations that included provision[1] for purchase and removal.

Another factor which influences flood losses is the extreme flood event. Floodplain regulations generally are related to the 100-year flood. Therefore, new development which takes place under Scenario II would not be at risk from the 100-year flood, but would still be vulnerable to flooding from events greater than the 100-year flood. The significance of the floodplain beyond the 100-year flood limit has not been researched. In the absence of such data, it is necessary to calculate its significance based on several assumptions which build upon fragmentary data. Floods greater than the 100-year event accounted for 61 percent of the nation's reported flood losses from 1959 to 1974.[1] The significance of these greater floods can be demonstrated in 62 Appalachian counties where between 1970 and 1976, flood stages at various sites equaled or exceeded the 100-year flood stage.[2] It has been estimated that on a nationwide basis, the 500-year floodplain is only about 25 percent larger than the 100-year floodplain.[3]

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[1] Sheaffer & Roland, Substantial Improvement, p. 56.

The losses from floods greater than the 100-year flood would occur both within and outside the 100-year floodplain. Empirical data is not available with respect to the distribution of occupance within the 500-year floodplain.

They can be estimated however, by making several assumptions wich are supported by empirical data. To arrive at an estimate of the distribution of flood losses between the 100-year floodplain and the area outside the 100-year floodplain but within the 500-year floodplain limit the following theoretical calculations were made. The assumptions are that the 500-year floodplain is 25 percent larger than the 100-year floodplain and that there is uniform distribution of occupance throughout the 500-year floodplain. It also assumes that all of the floods greater than the 100-year events would be 500-year events (although the majority would be smaller). This exercise indicates that losses within the 100-year floodplain would be as follows:

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[1] Sheaffer & Roland, Mitigation, Table 9, p. 49.

[2] Jack Faucett and Associates, Natural Hazards in Appalachia: Executive Summary (Washington, D.C.: Appalachia Regional Commission, September 1977), p. 15.

[3] Federal Insurance Administration estimate, 1977.

a) 40 percent of all losses would occur from floods affecting only the 100-year floodplain;

b) assuming a uniform distribution of the losses over the 500-year floodplain, four-fifths, or 48 percent, of the losses from the greater events would occur within the 100-year floodplain (the 25 percent of the 500-year floodplain that is outside the 100-year floodplain constitutes one-fifth of the floodplain); and

c) thus, 88 percent of the losses (40 percent plus 48 percent) would occur within the 100-year floodplain.

When all the factors which affect losses are considered, it was estimated that the total average annual 1990 flood losses would increase by 71.1 percent over 1975 levels under Scenario I. In Scenario II, which permits construction of elevated buildings in the floodplain, a significant reduction in flood losses is achieved relative to losses that would be incurred without regulations. This scenario allows losses to increase by 10.4 percent by 1990. This results from losses to existing structures at risk and the losses associated with floods greater than the 100-year event. Only Scenario III regulations result in the immediate and long-term absolute decrease of flood losses.

Development Potential

Floodplain regulations had been alleged to have the capability to change the economic development potential of a community. A loss of anticipated development and a reduction in the anticipated tax revenue in a case study area would indicate such a change.

The value of new construction and net demolitions that would occur under each scenario was projected in each case study. Inter-scenario comparisions of the changes in local tax base were then made. The Scenario I tax base in 1980 and 1990 was used as the measure of change in the desired development potential.

Under the projected scenarios, floodplain regulations would not result in the significant loss of any anticipated development potential nor would they cause a reduction in tax revenue. Moderate regulations, Scenario II, appear to have the potential to actually enhance the local tax base through increased development as reflected in flood proofing.

Even where the economy is dependent on proximity to the water's edge and/or where there is no alternative means of satisfying these locational needs within the case study area, the effects on development potential under Scenario III would be small. The rate of removal of existing structures contemplated under Scenario III would proceed at the rate estimated under the analysis of substantial improvement regulations (3 percent over 10 years). This removal would reduce existing development on the floodplain. However, the remaining development in such a situation will appreciate because of the reduction in supply thereby offsetting what could have been a reduction in the local tax base.

It must also be recognized that Scenario III regulations produce economic effects that may be perceived to be undesirable by current owners of undeveloped property. Upzoning to lower intensity of open space uses could cause possible wipeouts of anticipated but as yet unrealized windfall profits. Such speculation is often based on the calculated risk that down zoning to high intensity uses can be secured. In this sense Scenario III regulations do not unduly wipeout existing property values. The effects of such speculation wipeouts does not affect the tax base, for the anticipated windfalls are not entered on the tax rolls.

Social Effects

Social effects of floodplain regulations can affect individuals, families, and organized associations of people such as municipalities. This discussion of effects will focus on the nature and degree to which projected alternative regulatory scenarios expose people to flood hazards.

There are a number of complex methodologies that relate to the social effects of regulations (see Chapter III). However, the detail of data required for such approaches could not be developed within the scope of this research effort. Therefore, a simpler and more straightforward way of evaluating the social effects of floodplain regulations was derived. The approach used was to determine the number of people that would be at risk as a consequence of each scenario. This approach does not address the types of people or their activities but does provide the basic population estimates from which one could derive some of this information.

The number of floodplain residents at risk from the 100-year flood as currently delineated in the sample communities in the unregulated Scenario I is projected to grow by 33.3 percent by 1990 (see Table I9). In contrast, in Scenario II and Scenario III the 1990 population at risk would be reduced by 6.9 and 6.6 percent, respectively.

In comparison with Scenario I, under Scenarios II and III, residents of the 100-year floodplain of the case study areas will be less threatened and inconvenienced by flooding and will be spared much of the time and expense of clean up as well as the trauma associated with an actual flood event.

On the other hand, the moderate regulations under Scenario II do not protect against the failure of the urban infrastructure, the disruption of normal activities, and the physical isolation of households. In addition, the floodplain development under the Scenario II regulations would still be affected by floods greater than the 100-year flood. The condition of exposure would be changed significantly, however. Flood proofed structures generally would not be exposed to deep flooding. Rather their exposure would be to the difference in depth between the 100-year flood stage and the greater flood. While it is true that the effects of these events will be lessened, floodplain residents will continue to be periodically inconvenienced.

When a structure is adjusted to reduce flood losses, there is a tendency to overestimate the benefits, e.g., it is assumed that the flood proofed structures are safe from all flooding. There is a significant difference, however, when the residual risk is compared with occupants protected by levees and dams. When a levee or dam fails, the occupant is deluged with the full effects of the flood event. The resident of the flood proofed structure, on the other hand, will experience only the problem resulting from the difference between the 100-year flood and the higher flood.

Environmental Effects

Floodplain regulations have the potential to affect the environmental quality of an urban area. Prevention of further development of the flood hazard area helps to maintain the water supply, the natural floodplain storage and wildlife benefits of the floodplain ecosystems. As illustrated in Table 20, Scenario I allows the rapid conversion of floodplain open-space to urban uses. Scenario II slows considerably the conversion of floodplain lands to development, thus helping to preserve and enhance the natural features of the floodplain. Scenario III prevents further conversion of floodplains to development and, in fact, begins to recoup urbanized land for open space purposes.

While urbanization proceeds throughout the aggregate study area under all scenarios, there are differences in development trends in the floodplain. In both Scenarios I and II, vacant floodplain land is urbanized. By 1990, in Scenario I, 22,100 new acres of the floodplain would be developed. Scenario II would reduce this conversion to 13,900 acres. In Scenario III, however, this trend is reversed; by 1990, developed floodplain acreage would begin to revert to open space (see Table 20). Thus, Scenario III alone holds some promise as a corrective approach in already developed floodplains.

Environmental effects of floodplain regulations can be discussed in terms of quantity (flood stages) and water quality. This is done in the following sections.

Flood Stages

A direct environmental result of floodplain occupance would be an increase in flood heights for a given flood event. Fill in the floodplain to create suitable building sites can both eliminate natural floodplain storage and obstruct flood flows. When this is done, the elevation of a given flood event can be raised. Such fills in natural groundwater recharge areas also have the potential to reduce the rate of replenishment to groundwater supplies thereby diminishing available water supplies. In this context floodplain regulations as they relate to fills have potential effects on both flood stages and groundwater supplies.[1]

It should be noted that these observations pertain to riverine areas. The effects of development on the level of flood waters and water supplies in coastal zones would be small. However, the salt marshes and barrier beaches of coastal areas would absorb some of the enormous energy of waves driven by storms. In Scenario I and to a much lesser degree, Scenario II, coastal area development would destroy and encroach on these ecosystems and itself absorb the force of storm waves. Scenario III would prevent the development of these coastal zones and begin to recapture some of them and their attendant benefits. Thus, the value of regulations in coastal areas is in the mitigation of damages and in the preservation of natural ecosystems with their aesthetic, recreational, and resource values.

Water Quality

Floodplain regulations have the potential to affect water quality. The practice of locating sewage treatment and solid waste disposal facilities in "low areas" frequently means floodplain locations which discharge leachates and other pollutants into waterways. Also, nonpoint sources of pollution associated with floodplain development would have direct access to the waterways. In addition, such development would affect low flows in the waterways. The scope of this study did not permit the quantification of environmental effects of future floodplain occupance.

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[1] A.O. Waanien, et al., Flood Prone Areas and Land-Use Planning (San Francisco: U.S. Geological Survey Professional Paper 942, 1977).

The fill and paving associated with floodplain development would affect water quality in two ways. First, they would contribute to non point sources of pollution associated with urban stormwater runoff. Second, such fills would restrict inflow into the groundwater reservoir. Since the discharge of groundwater to surface streams constitutes the base flow of many waterways during dry periods, the increased runoff would reduce low flows, the periods of poorest water quality.

From another perspective, the sewerage facilities that accompany such urbanization--mains and treatment plants--frequently would be overloaded during periods of flooding and would surcharge or bypass pollutants to the waterways. These conditions would contribute to water pollution. Also, the location of solid waste or sanitary landfills on floodplains would result in the discharge of highly polluted leachates into waterways while at the same time would encroach on the valley cross sections which would increase up stream flood heights.

The further development associated with Scenario I would lead to further deterioration of environmental quality. The regulations associated with Scenario II would tend to stem that tide by preserving some of the existing natural treatment processes of the floodplain ecosystems. Scenario III would both preserve those processes and begin to increase them. Open space programs that preserve and enhance such ecosystems along streams, lakes and drains would help to purify urban runoff and thereby improve water quality. This would be done by the filtering actions of the floodplain vegetation (a process similar to overland flow) and therenovative capacity of marshes and their vegetation (phragmites) which have the capability both to remove nutrients from stream flows and to add oxygen.

In addition, Scenario III prevents all new building and filling of the floodplain. Thus, expansions to sewage and solid waste treatment facilities would have to be located outside the floodplain. Recent demonstration projects show the practicability of areawide land treatment of sewage and alternative means of solid waste management outside the floodplain.[1] Scenario III prohibits new structures in the flood hazard area. Thus, it can help stimulate new approaches to wastewater management that are encouraged by the Clean Water Act of 1977.[2] This Act encourages approaches that regard pollutants as resources out-of place to be processed and recycled.

Multipurpose Benefits of Floodplain Open Space

Floodplain open space would provide a number of benefits in urbanized areas These include preservation of natural floodplain storage, avoidance of encroachment on valley cross sections, preservation of natural groundwater recharge, maintenance of ecosystems, improvements in water quality, and provision of recreational opportunities. The possible integration of such benefits was outlined by the Secretary of the Army when he observed:

> Why not use our flood plain in urban areas for crop production, golf course, forests, and other uses which can capitalize on the nutrients in our wastewater and provide tertiary waste treatment at the same time? Such land treatment sites can be located on the higher areas of the floodplains, but they can also be designed to store flood water when necessary without permitting the release of the stored water except through the soil filtration process.[3]

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[1] U.S. Environmental Protection Agency, Wastewater: Is Muskegon County's Solution Your Solution? (Chicago: U.S. EPA, Region V., 1976).

[2] Public Law 95-217.

[3] Charles R. Ford, "Effect of New Legislation on Management of River Systems", Transactions of the 40th North American Wildlife and Natural Resources Conference (1975).

Urban stormwater runoff in coastal hazard areas and the discharge of sewage effluent produced by the urban areas affect the coastal ecosystem and their food chain characteristics. Significant effects have strong economic implications for beach activities; commercial fishing, and sport fishing are all dependent on clean water.

A National Urban Perspective

The case study communities selected reflect a range of urban flood situations in the country. Although there may be questions as to its "representativeness" in a formal statistical sense, it is a systematic sample that comprises a large sample of the NFIP flood-prone community characteristics. Thus, the case studies can be used to provide some indication of the effects of floodplain regulations on a national basis.

To begin to develop this perspective, in 1975 there were an estimated 162,800 dwelling units (13.5 percent of all dwelling units) in the floodplains of the study communities. Of this total, 53.7 percent of them (87,400 structures) were at risk from the 100-year flood. From a national viewpoint, the data from the Federal Insurance Administration and the Annual Housing Survey were used to estimate the total number of dwelling units in the nation's urban floodplains. An estimated 7.4 million dwelling units are located on the nation's floodplains. However, it is estimated that only 4.0 million dwelling units are at risk from the 100-year flood (assuming the same percentage at risk as in the case study communities). Thus, the dwellings at risk in the study communities account for 2.21 percent of all dwellings at risk throughout the country.

The 1975 population of the sample communities was approximately 3.5 million. This was 1.99 percent of the estimated 175.2

million people living in the communities designated by FIA as having areas of special flood hazard.

The aggregate average annual flood damages in 1975, for all study communities is estimated at $76.6 million. This represents 6.30 percent of the nation's $1.2 billion in average annual urban flood losses as estimated by the Water Resources Council. While the sample communities represent about 2 percent of the dwellings and people at risk, they are weighted more heavily toward communities with above average flood losses. Part of the explanation for this is the fact that the sample is also weighted quite heavily toward communities with large floodplains (see Chapter IV).

As suggested earlier, one reason for selecting communities with relatively large flood hazard areas with severe flood problems was to insure that the empirical results reflect the areas in which the effects of floodplain regulations would be most pronounced. This particular sample may be most useful because it reflects urban development pressures throughout the various parts of the nation. The economic, social, and environmental effects of floodplain regulations are not likely to be great where there is little growth projected for floodplain areas.

Keeping these sample characteristics in mind, estimates were generated of the effects of floodplain regulations throughout the nation. These projections are limited to the effects on housing, population, developed acreage, and urban flood losses. The rates of change for these parameters are identical to and derived directly from those found in aggregate case study area projections. Thus, the dimensions of national changes are presented along with a discussion of the changes in the floodplain's share of housing and developed land uses. This provides some insight, at the national level, into the effects of each scenario.

Housing

On the basis of the case study findings, floodplain housing units accounted for 13.5 percent of the units in 1975. However, only 7.2 percent of them were at risk. These percentages were applied to the national housing stock figures to arrive at national estimates. Table 22 extends projected housing for the sample to the nation's urban floodplains.

Allowing the market to govern future development without floodplain regulations (Scenario I) would produce a net increase of nearly 2.6 million homes in the floodplain by 1990, for a total of 9.9 million units. The number of units that would be subject to risk from the 100-year flood would approach 5.3 million, an increase of 1.3 million.

Scenario II regulations would allow the housing stock in the floodplain to increase by 1.6 million to 8.9 million in 1990. The number of units at risk, however, would decrease by 185,000 to 3.8 million as a result of compliance with elevation requirements.

In Scenario III, both the total floodplain housing stock and those at risk would be reduced by 1990. Some 276,000 homes would be removed from the floodplain, leaving a residual of less than 7.1 million. Of the 1975 housing stock at risk, 171,000 would be removed leaving a residual of 3.8 million dwelling units at risk.

Table 22: Projected U.S. Urban Floodplain Housing Stock: 1975-1990

	Housing Units			
	Floodplain		At-Risk	
Date	Number	Percent of all Housing	Number	Percent of all Housing
1975	7,356,000	13.5	3,950,000	7.2
1980				
Scenario I	8,320,000	13.7	4,460,000	7.3
Scenario II	7,967,000	13.1	3,785,000	6.4
Scenario III	7,523,000	12.0	3,879,000	6.4
1990				
Scenario I	9,931,000	13.9	5,265,000	7.4
Scenario II	8,945,000	12.5	3,764,000	5.3
Scenario III	7,083,000	10.0	3,780,000	5.3

Population

In 1975, the estimated urban floodplain population for the agrregate case studies was 480,500, or 13.8 percent of the total study area population. If the study area is taken as 1.99 percent of the nation's floodplain population, there were 24.1 million floodplain residents in the nation in 1975.

In the sample 55.3 percent of the floodplain occupants, or 265,500 people were found to be at risk from the 100-year flood. Using this same percentage, there were 13.3 million at risk nationally.

Table 23 extends the projections for the case study areas to the nation's urban floodplains. Between 1975 and 1990 under Scenario I, the floodplain population would increase some 7.0 million, or 29 percent. The population at risk also would increase by 4.5 million, or 33 percent. Moderate regulations would allow the floodplain population to grow 4.1 million, or 17 percent, while achieving a 925,000 decrease (7 percent) in the population at risk. Scenario III regulations would reduce the actual number of floodplain occupants by 1.3 million (6 percent). Also, it would reduce the number of people at risk by about 900,000 (7 percent).

Land Use

The flood hazard area was 17.8 percent developed in the aggregate study area in 1975. From the case study areas, a national estimate of developed urban floodplain acreage for 1975 of 4.3 million acres was derived. Projections showed that the rate of urbanization in the floodplain declined with the increasing stringency of regulations. Extending these results to the nation's urban floodplains, the urbanization of the floodplain continues unabated under Scenario I, while the rate of increase is slowed by Scenario II and reversed by Scenario III. Table 24 shows that between 1975 and 1990 in Scenario I, an additional 1.6 million floodplain acres would be developed for urban purposes. In Scenario II an additional 1.0 million acres would be urbanized. In contrast, Scenario III would result in the clearance and retrieval of 69,000 acres for floodplain open space.

Another way of viewing this response to regulations is to examine the change in the floodplain's share of total development among the three scenarios. In 1975, the flood hazard area comprised 12.9 percent of the development in the aggregate study area. Table 24 shows the relative changes in this statistic

Table 23: Projected U.S. Urban Floodplain Population: 1975-1990

Date	Estimated Population Floodplain	At Risk
1975	24,146,000	13,342,000
1980		
Scenario I	26,995,000	15,130,000
Scenario II	25,784,000	13,115,000
Scenario III	23,628,000	13,121,000
1990		
Scenario I	31,121,000	17,789,000
Scenario II	28,286,000	12,417,000
Scenario III	22,799,000	12,457,000

Table 24: Projected U.S. Urban Floodplain Developed Areas: 1975-1990

Date	Developed Floodplain Acreage Acres	As a Percentage of Total Development
1975	4,342,000	12.9
1980		
Scenario I	4,972,000	13.3
Scenario II	4,724,000	12.6
Scenario III	4,312,000	11.6
1990		
Scenario I	5,957,000	12.5
Scenario II	5,384,000	11.3
Scenario III	4,273,000	9.1

wrought by regulations. Without regulations, the flood hazard area's share of the total urban development increases by 1980 and then begins a slight decrease in the percentage of total development. Scenario II shows a larger decline by 1990. Scenario III, however, steadily reduces the floodplain's share of total development. All new development and all substantial improvement candidate structures would be relocated outside the flood hazard area.

Flood Losses

Aggregate flood losses for the case study areas were estimated in 1975 to constitute 6.30 percent of total average annual losses of $1,215 million for U.S. urban areas.[1] Future estimates of flood losses for the three scenarios were extrapolated from these data. The results are presented in Table 25 and are depicted graphically in Figure 2 (page 21). The table shows a rapid rate of increase for Scenario I. Scenario II would hold the increase in losses to a moderate level, while Scenario III effects would result in an absolute decline in flood losses.

Future urban flood loss projections have been made by the Water Resources Council. The Council extrapolates total national losses to be $3,929 million in 1980 and $4,707 million in 1990 for the "current management" case; and $3,750 million in 1980 and $4,139 million in 1990 for the "modified central" case. Urban flood losses are projected by the Council to be $1,460 million by 1980 and $1,812 million by 1990 under the "current management" case. Urban flood losses under the "modified central" case (one that involves a decisivie shift toward nonstructural policies) are estimated to be $1,330 million by 1980 and $1,483 million by 1990.

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[1] Derived from U.S. Water Resources Council, Flood Damages.

Table 25: Projected U.S. Average Annual Urban Flood Losses: 1975-1990 (In millions of 1975 dollars)

Date	National Urban Flood Losses	Water Resource Council Explorations	
		Current Management Case	Modified Central Case
1975	1,125	1,215	1,215
1980		1,460	1,330
Scenario I	1,564		
Scenario II	1,260		
Scenario III	1,213		
1990		1,812	1,483
Scenario I	2,079		
Scenario II	1,341		
Scenario III	1,208		

a-Developed from case study area analysis

The two WRC estimates fall between the estimates of Scenario I and II. The WRC's "current management" case involves the implementation of minimum floodplain regulations in a manner analogous to current efforts. Its 1980 divergence from the Scenario II estimates is due to the total compliance assumed in Scenario II. Through time, the "current management" case produces results that approach Scenario I or no regulations.

The "modified central" case more nearly parallels Scenario II. The nonstructural policies embraced in this model assist floodplain regulatory efforts to achieve a degree of hazard mitigation. The average annual urban flood losses for the "modified central" case are 16% above the Scenario II estimates in 1980. By 1990 there is only a 10% difference.

The WRC results corroborate the projections of future urban flood losses developed from the results of the case study areas. In this sense, the case study areas can be viewed as a workable depictions of the national urban floodplain scene.

National and local policies with respect to flood losses appear to be oriented toward the minimization of losses, not the mere retardation of the rate of increase. If this policy is to be achieved, either Scenario III or Scenario II with corrective elements will need to be applied.

The research results show that Scenario II will greatly reduce the rate of increase of flood losses, but will not produce a decline in such losses. To achieve a decline in the present level of flood losses, a strong national effort must be made to correct past land use decisions that have resulted in unwise floodplain development. This can be achieved through either a modified Scenario II that incorporates effective corrective measures or Scenario III.

Findings

Floodplain regulations have the capacity to shift development from the 100-year floodplain to the area above the 100-year flood elevation. The dimensions of this shift vary with the nature of the regulations. Scenario II (moderate regulations) causes the shift to be either vertical (elevated buildings) or horizontal beyond the 100-year floodplain. Scenario III (stringent) regulations) allows only a horizontal shift. On the other hand, regulations do not prevent urban growth. Desired urban growth could be accommodated in nonhazard areas generally within the community and always within the economic region.

Housing

Between 1975 and 1990, the net increase in dwelling units at risk under Scenario I would increase by one-third. Under Scenario II during the corresponding period, the number of units at risk (vulnerable to the 100-year flood) would actually decline by nearly 5 percent since all new buildings would comply with elevation regulations and be either elevated on their sites in the floodplain or located beyond the 100-year floodplain. Scenario III would cause the complete transfer outside the floodplain of all the new floodplain housing that is projected for Scenario I; during the same period, the decline in the number of units at risk from the 100-year flood would be similar to that achieved by Scenario II. Only Scenario III can reduce the risk from all flood events as seen by the absolute decline in average annual flood losses it produces.

Population

Under Scenario I the popualtion at risk would increase by one-third by 1990. Scenario II regulations would cause the new floodplain occupants projected under Scenario I to locate either outside or above the 100-year flood hazard. Occupants of new floodplain housing would not be vulnerable to the 100-year flood and due to the attrition of nonconforming housing, the population at risk would drop by nearly 7 percent. In Scenario III the population increase would be fully accommodated outside the floodplain and the decrease in population at risk would be similar to that achieved in Scenario II.

It is important to note that Scenario II and III are about equally effective in reducing the population at risk from a 100-year flood. However, the number of persons exposed to floods which exceed the level of the 100-year flood under Scenario II would be greater because of the vertical elevations within the 100-year floodplain. Thus, the social effects of Scenario II in terms of inconvenience, disruption and trauma that would be encountered when floods occur would be greater.

Land Use

Without regulations, the rate of urbanization of vacant floodplain land would be greater than in nonhazard areas. With moderate regulations (Scenario II) the rate of development in the floodplain would be slowed and some of the development would be shifted outside the floodplain. This chiefly would be due to the transfer outside the floodplain of more than one-third of the residential and commercial development and one-fourth of the industrial development that would have occurred in the floodplain under Scenario I. In Scenario III, there would be a shift of all new development from the hazard area and developed floodplain land slowly would be returned to open space uses. Environmental quality, in terms of ecosystem management, flood stages, water supply, and water quality would be affected by regulations. The effects would be related to the amount of open space that is preserved or recouped in the floodplain.

Flood Losses

Without regulations (Scenario I), average annual flood losses were projected to increase by 70 percent between 1975 and 1990. Moderate regulations (Scenario II), which expose new buildings only to floods more extreme than the 100-year design event, would restrict this increase to 10 percent by 1990. Stringent regulations (Scenario III), which allow no new building and which contain corrective measures that program the removal of nonconforming structures would realize an absolute decrease in average annual flood losses of 1 percent by 1990.

National Assessment

Case study projections were extrapolated to portray future urban floodplain occupance characteristics and flood losses under each scenario. The results are shown in Table 3 (page 19). Scenario I increases population and housing exposure, allows losses to escalate, and contributes to environmental disruption. Scenario III achieves reductions in floodplain occupance and flood losses and is consistent with the intent of the National Flood Insurance Act and Executive Order 11988. Furthermore, it preserves and enhances environmental values with the attendant open space and recreational benefits. The effects of Scenario II fall in between those of Scenario I and II, but tend towards those of Scenario III.

Floodplains can be managed to achieve flood losses. Such management programs were initiated by the Tennessee Valley Authority in the seven valley states in the mid 1950s. The programs went beyond the simple enactment of flood regulations. By providing encouragement and assistance to local governments to guide new development away from floodplains, future flood losses were avoided and floodplain open space was preserved in harmony with local goals and objectives. Specifically, opportunities were identified and programs formulated to implement them.

It appears that if the corrective elements of Scenario III are added to Scenario II, the effects would closely approach those of Scenario II. Such a program would assist communities to achieve their comprehensive community development goals while at the same time to reduce their flood losses. It would also reduce national flood losses, a goal envisioned in Federal flood-related legislation enacted since 1936.

GLOSSARY

100-year floodplain, That part of the natural floodplain subject to inundation by the 100-year flood (a flood event that has a one percent chance of occurring in any given year).

Development, Uses of land for residences (including yards) mercial and industrial establishments and public and private institutions, public utilities, transportation facilities (streets, roads, railroads, and airports), parking lots, and buildings used for recreation (but not open spaces in parks).

Flood Fringe, The portion of the floodplain outside of the floodway (sometimes referred to as "floodway fringe").

Flood Hazard Area, The same as the 100-year floodplain.

Floodplain, The same as the 100-year floodplain. Where a larger floodplain is referred to, it will be noted appropriately.

Flood proofing, Adjustments to structures, facilities, sites, and contents which are designed or adapted primarily to reduce flood damages.

Floodway, The channel of a river or other watercourse and the adjacent floodplain areas reserved in an open manner to provide for the discharge of the 100-year flood so the cumulative increase in water surface elevation is limited to no more than one foot.

Hazard area, The same as the 100-year floodplain.

Housing At Risk, Those housing units situated within the 100-year floodplain whose first habitable floor is at or below the elevation of the 100-year flood.

NFIP Emergency Program, Refers to the status by which communities participate in the NFIP prior to the existence of flood insurance study reports and rate-making maps.

NFIP Regular Program, Refers to the status by which communities participate in the NFIP following the effective date of a flood insurance study and flood insurance rate map.

Nonhazard Area, The area outside the 100-year floodplain. It includes flood-free areas as well as areas in the natural floodplain subject to inundation by floodwaters from a flood event larger than the 100-year flood.

GLOSSARY (continued)

Population At Risk, That portion of the population of the 100-year floodplain inhabiting housing at risk.

Special Flood Hazard Area, The 100-year floodplain. The term has been used nationally by the FIA during recent years.

Substantial Improvement, The same as in the NFIP regulations. These regulations require that repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds 50 percent of the value of the structure, must comply with the prescribed regulations relating to floodplain building practices (e.g., flood proofing or elevating the structure above the level of the 100-year flood).

APPENDIX A

JUDICIAL RECOGNITION OF EFFECTS OF FLOODPLAIN REGULATIONS

Judicial Recognition of Effects of Floodplain Regulations

As society becomes more aware that land, water and air are not commodities that can be abused without long-term and perhaps even irreversible negative impacts, State and Federal courts are upholding regulations which even a decade ago would have been struck down. They are broadening their interpretation of public health, safety, and welfare and recognizing an array of public harms which such regulations are seeking to prevent. Testimony presented in these cases is becoming increasingly scientific, and with this improved factual basis, courts are making new decisions which will have wide ranging effects. By floodplain regulation we refer to any array of techniques designed to keep people away from the water, as contrasted to structural measures (dams, dikes, levees, seawalls, etc.) designed to keep the water away from people. Floodplain regulation techniques include: comprehensive planning; building codes and building permits; floodplain zoning; subdivision regulations; site plan review; water supply, sewerage, drainage and erosion control regulations; utility location regulation; tidal and fresh water wetlands regulations; environmental regulations; set-back lines; acquisition and relocation. Floodplain regulations are widely accepted as an appropriate exercise of the police power by a duly constituted legislative body. Regulations are presumed to be valid if they:

1. conform to and do not exceed the authority granted in enabling statutes (generally related to explicit objectives or implicity derived from health, safety and welfare provisions);
2. adhere to the doctrine of reasonableness; i.e., do not unreasonably deprive property owners of all economic benefits; and
3. forbid arbitrary or discriminatory treatment; i.e., require equal treatment for similarly situated properties.

Economic Effects

A basic tension exists between the rights of the private property owner to use his property, unencumbered by regulation, and the responsibility of all levels of government for the health, safety and well-being of their citizens. As noted in the previous section, landowners bitterly denounce perceived diminution in property values resulting from floodplain regulations. Governments are accused of taking property without just compensation; rendering unmarketable private property located in identified floodways; being forced to sell property or to pay taxes not commensurate with the use permitted; and incurring increased construction costs that result from such regulations.

Change in Value and Economic Uses of the Property Being Regulated: - The most common attack on land use controls is that regulations are an unconstitutional taking of private property without just compensation, in violation of the 5th Amendment of the Constitution. In Pennsylvania Coal Co. v. Mahon, 260 U.S. 393 (1922), the U. S. Supreme Court ruled that one of the considerations in deciding whether a regulation exceeds its constitutional limits is the degree in which the value of the property has been diminished. In Euclid v. Ambler, 272 U.S. 365, (1926) the Court was not persuaded by a value differential, holding that before a zoning regulation can be declared unconstitutional it must be found to be clearly arbitrary and unreasonable, having no substantial relation to public health, safety, morals, or general welfare. Then in 1962 the Court reiterated that there is no set formula to determine where legitimate regulation ends and taking begins, and that while a comparison of values before and after regulation is relevant (citing Pennsylvania Coal), it is by no means conclusive. Goldblatt v. Hempstead, 369 U.S. 590 (1962).

State courts have universally maintained that the stringency of regulation must be reasonably related to the severity of the public harm being mitigated by the regulations. MacGibbon v. Board of Appeals of Duxbury, 356 Mass. 696, 255 N.E. 2nd 347 (1970). After a number of cases across the country found taking to be the issue, in Massachusetts the court held that even a substantial (88 percent) decrease in value of rezoned property is not a conclusive argument against the rezoning. Turnpike Realty v. Town of Dedham, 362 Mass. 221, 284 N.E. 2nd 891 (1972), cert. identified 409 U.S. 1208.

With little fanfare state courts in Wisconsin and New Hampshire have taken a giant step on the issue of the value of the property being regulated. Prior courts had almost always focused on the market value, that is the "value" of the property as viewed in the real estate market in terms of the profit which can be derived from the land for an individual or small segment of society. These two courts, however, have analyzed the worth of the property in light of what might be called its intrinsic value, based on its role in the ecosystem, related to its value to society as a whole.

In Just v. Marinette County, 56 Wis. 2d 7, 201 N.W. 2d 761 (1972) the court held that an owner has no absolute and unlimited right to change the essential natural character of his land so as to use it for a purpose for which it is unsuited in its natural state and which injures the rights of others (here, the rights of the public to preserve the natural environment and the natural relationship between the wetlands and the purity of the water and natural resources). Regarding value, the Court pointed out that the alleged depreciation was not based on the use of the land in its natural state, but on what the land would be worth if it could be filled.

> "While loss of value is to be considered in determining whether a restriction is a constructive taking, value based upon changing the character of the land is not an essential factor or controlling." (201 N.W. 2d at 771)

The New Hampshire court embraced this rationale in Sibson v. State 115 N.H. 124, 336 A.2d 239 (1975), stressing:

> "The denial of the permit did not depreciate the value of the marshland or cause it to become 'of practically no pecuniary value.' Its value was the same after the denial of the permit as before and it remained as it had been for millenniums... (336 A.2d at)

and that no taking had occurred because the denial prevented public harm (rather than create a public benefit). Under the old Pennsylvania Coal diminution of value test, however, a logical conclusion of the argument above is that since there is no change in value, there is obviously no diminution in value in such circumstances, and therefore there is also no taking.

Protection of Properties Other Than the Regulated Property: - Floodplain controls also affect properties other than regulated property. A few courts have recognized the hazards of floodplain encroachment on other properties. In Turner v. County of Del Norte, 24 Cal. Rptr. 93 (1972), the court stated that the floodplain regulations which prohibited further buildings in a subdivision subject to flooding, and permitted only parks, recreation, and agriculture, were a valid exercise of the police power. Evidence showed that such buildings would increase flood heights which could increase the hazard to other buildings outside of the zoned area. Other similar examples include temporary moratorium (Cappture Realty Corp. v. Board of Adjustment, 126 N.J. Sup. Ct. 196, 313 A.2d. 624 (1973)), rejection of fill permits (Turnpike Realty Co. v. Town of Dedham, 362 Mass. 221, 284 N.E. 2d 891 (1972), cert. denied, 409 U.S. 1208) and denial of building permits (Vagga Properties, Inc. v. City Council of Woburnn, 296 N.E. 2d 220 (Mass. Ct. App. 1973)), where proposed construction would affect flood stages upstream, downstream, or on adjacent properties.

Higher Cost of Development Due to Compliance with Regulations: - If the property is located in a floodplain zone where, in order to develop, the structure would have to be flood proofed or fill placed on the site to raise it above the regulatory flood level, additional costs to comply with floodplain regulations are usually involved. While there are no cases as yet specifically testing such building regulations, conceptually they are no different than others which local governments have established in their building codes or subdivision regulations. The necessary expense or loss of value which will be sustained by the property owner as a result of the regulations does not invalidate such regulations, e.g., City of Chicago v. Washington Home of Chicago, 289 Ill, 206, 124 N.E. 416 (1919).

Loss of Tax Base: - One argument raised in opposition to floodplain/wetland regulation is that otherwise developable land cannot be developed, causing a hardship on the community because of a loss of tax base. No case has been found to support this view. Instead, courts have enumerated public benefits gained and public harm prevented. Even those courts which have struck down regulations have recognized the benefits, but have decided that to obtain such benefits, eminent domain rather than police power was the legitimate tool. (State v. Johnson, MacGibbon v. Board of Appeals of Duxbury and Morris County Land Improvement Company v. Parsippany-Troy Hills Township, 537, 193 A.2d, 232 (1963).)

There is recognition, on the other hand, that a regulation may protect the tax base. (CF., Just v. Marisette County, 56 Wis. 2d F. 201 N.W. 2d 761 (1972); Cappture Realty Corp. v. Board of Adjustment 126 N.J. Sup. Ct. 196, 313 A.2d 624 (1973).)

Even assuming that regulations do result in a lower assessed valuation for floodplain properties, there may still not be a tax base loss in totality for the community. Often there is other land, outside of the flood hazard area but still within the tax jurisdiction, which is better suited for the development. In that case there is no net loss, just a shift to a more appropriate location.

Avoidance of Public Liability: - The finding of public liability in the floodplain has generally been in cases where a governmental entity has built something which caused damage to private property at times of flooding. (Barr v. Game, Fish and Parks Commission, 30 Colo. App. 482, 497 P. 2d 340 (1972). City of Vicksburg v. Porterfield, 164 Miss. 581, 145 So. 355 (1933). Beckley v. Reclamation Board of State, 205 Cal. App. 2d 734, 23 Cal. Rptr. 428 (1962).)

There is as yet no decision that finds a government entity liable for allowing a private structure to be built which causes flood damages to another's property. Such potential liability is suggested, however, in Cappture Realty.

The most important role of floodplain land may be that of carrying floodwaters, especially since the filling or development of such land shifts the burden of carrying floodwaters onto other lands which in the original, natural order of things did not have to function in that role at all. In addition, the pre-regulation market value of property in a hazard area was unrecognized or not widely known. Land may be on a geologic fault, an old mudslide, or subject to avalanches. When these geologic hazards become widely known, its development potential and its price should decrease, with or without regulation. The regulation may simply be a recognition of this unsuitability by the general public.

Social Effects

Social effects recognized by the courts relate to protecting the health, safety and welfare of floodplain residence.

There is an increasing potential for public liability in the floodplain. With improved meteorological and hydrological information, the occurrence of a flood of a certain magnitude becomes a statistical probability, and the age-old rationale for negligence as an "act of God" becomes suspect. As more of the nations floodways and floodplains are mapped, local governments will have difficulty pleading that they were ignorant of the dangers when new developments, which they permitted, are destroyed and lives lost. In regard to existing development in the floodplains, courts are already recognizing that additional filling and development raise flood heights, alter flows, and increase the hazard to the existing development. Logically, the next step is likely to be the finding of a local government liable for permitting such development when it had knowledge of potential flood hazards.

Protection of Lives and Property, Including the Urban Infrastructure: - Developers of floodplains, who may or may not be aware of the risk, are in and out of the property within a few years, selling it to unwary buyers. Encroachment affects other individuals and the public. The loss of lives and property, of public facilities such as utility lines and roads to serve floodplain development, or employment centers closed down because of flood damage, have a detrimental and long-term effect on the community as a whole.

Preservation of public health, safety, and welfare is the cornerstone for the exercise of police powers.

Regulations to minimize threats to public safety enjoy a presumption of constitutionality. Biffer v. City of Chicago, 278 Ill. 562, 116 N.E. 182 (1947). The Turnpike Realty case recognized that restrictions on land serve to protect those who might choose to develop or occupy the land in spite of the dangers to themselves or their property. In Turner v. County of Del Norte, the court held that where evidence showed a frequency of flooding which would almost certainly eventually destroy permanent residents and endanger the lives and health of their occupants, such developments can be prevented by zoning. (See also Vassa Properties.)

In Spiegle v. Borough of Beach Haven, 116 N.J. Sup. Ct. 148, 281 A.2d 377 (1971), the court recognized both the need to protect the owner from his own folly and the need to protect the public from his indiscretion. The court stressed the fact that ruptured sewer lines could endanger the borough's entire sewer system, a ruptured water line might result in the municipal tank being drained, and a ruptured gas line would also create a dangerous condition. Road service could not be provided or feasibly maintained over the beach. Under these circumstances, the court upheld the Borough's prohibition of building seaward of the dune line of the beachfront.

Courts are also recognizing the economic realities of floodplain development, with new development placing an additional burden on existing development and on the community as a whole. There is potential damage not only to the existing properties, but also to the infrastructure built and maintained with public funds to serve such development. Such development increases the demand for public flood control works, which the Cappture court pointed out would result in public expenditure for the benefit of specific private property.

Preclusion of Need for Public Expenditure for Protective Works and Disaster Relief: - As more and more development occurs in the floodplain, the flooding situation is aggravated, and there is clamor to build protective works such as dams, dikes and channels. At least one court has recognized that expending public dollars for such protective works may actually be a subsidy to private development. In Cappture Realty the court upheld a building moratorium until a flood control project could be built, and stated:

> "Although perhaps unnecessary for this decision, the other side of the coin is often overlooked in analyzing claims by a landowner in a flood area that he should be able to use his land without restriction. If private construction would

> call for, or perhaps demand or increase the demand for, public flood control projects, does this not call for an expenditure of public funds for the protection of a specific private property, or purposes?"

The Turnpike Realty court upheld the constitutionality of floodplain regulations which has as a major objective, the protection of the entire community from individual choices of land use which require subsequent public expenditures for public works and disaster relief.

Environmental Effects

Courts have recognized the natural functions of the floodplain and the problems that arise as a result of their loss. The reduction of storage capacity, groundwater recharge area, water quality, ecosystem quality and recreational areas have economic and social dimensions that transcend the land that is subject to regulation.

Preservation of the Flood Carrying Capacity and Storage Capacity: - A U. S. Supreme Court decision, Chicago & Alton R. E. v. Tranbarger, 238 U.S. 67 (1915), held that an act to prevent railroad embankments from deflecting surface water from its usual course, thereby injuring the land of another, was a legitimate regulation established under the state's police power.

In City of Welch v. Mitchell, 95 W.Va. 377, 121 S.E. 165 (1924), the court held that the City has the right to set equitable building lines on either side of a creek equidistant from the center in order to prevent obstruction of the flow of the stream.

In Vartelas v. Water Resources Commission, 146 Conn. 650, 153 A.2d 822 (1959), the court found the establishment of encroachment lines a valid means of maintaining the capacity of the channel and avoiding raising flood stages. Iowa Natural Resources Council v. Van Zee, 261 Iowa 287, 158 N.W. 2d 111 (1968), also recognizes the importance of this issue.

The Morris County Land Improvement Company court recognized the value of preserving swampland as a natural stormwater detention basin for waters, but that its preservation could not be accomplished by an exercise of police power. To obtain the public benefit, compensation for the land would have to be made. The Vazza Properties court, however, came to a different conclusion, holding that building a large apartment complex and parking area would aggravate a periodic flooding problem in nearby residential areas by eliminating a natural soft-peat holding area.

Preservation of Groundwater Recharge Area: - Cases in the area of water law have long recognized the hydraulic connection between surface waters and groundwaters, especially in the semi-arid West. In the California case of Miller v. Bay Cities Water Co., 157 Cal. 256, 107 Pac. 115 (1910), the court permanently enjoined a water supply corporation from building a dam, finding that the plaintiff, an orchard owner, had a right to the continued flows of flood waters to recharge his aquifer; these flood waters were those which could reasonably be anticipated during ordinary seasons.

In Turnpike Realty, the court upheld the town's ordinance establishing a Flood Plain District as a valid means of preserving and maintaining the groundwater table.

Protection of Water Quality: - The need to protect the quality of water for beneficial uses was recognized by the U. S. Supreme Court as early as 1931 in New Jersey v. New York, 283 U.S. 336, in which Mr. Justice Holmes made his oft-quoted statement, "A river is more than an amenity, it is a treasure."

A major effect of building in floodplains and wetlands is the degradation of water quality and aquatic life due to increased pollution and siltation of the waters. In Zabel v. Tabb, 430 F. 2d 199 (1970), cert. denied 401 U.S. 910, the court ruled that not only did the federal government have the power to prohibit for ecological reasons the dredging and filling on private riparian lands submerged in navigable waters, but that the Corps of Engineers was compelled to take such factors into account.

To similar effect, the District Court in United States v. Lewis, 355 F. Supp. 1132 (1973), pointed out that it was necessary to maintain the unrestricted ebb and flow through the network of small tidal streams of the salt water marsh because this had a cleansing effect on plant and animal life in the marshland.

This principle is upheld in state courts. In Candlestick Prop., Inc. v. San Francisco Bay C & D Com'n, 11 Cal. App. 3d 557, 89 Cal. Rptr. 897 (1970), the court upheld the denial of a fill application, citing the state act which stated that further piecemeal filling of the bay may adversely affect the quality of the bay waters and even the quality of air in the bay area.

The Just court based its decision in great part on the prevention of future pollution and eradication of present pollution. Recognizing the interrelationship between the wetlands and the natural environment of shorelands to the purity of the water, this court reaffirmed that laws to prevent pollution and protect the waters from degradation were valid police-power enactments.

Two years later, in State v. Deetz, 66 Wis. 1, 224 N.W. 2d 407 (1974), the same court overturned the traditional "common enemy" rule whereby a landowner has an unrestricted right to deal with surface water on his land as he pleases, regardless of the harm which he may cause to others. The court overturned this precedent and adopted the "reasonable use" doctrine of surface waters and remanded the case to the lower court to determine whether the conduct of the developer was reasonable.

In Brecciaroli v. Connecticut Commr. of Env. Protection, 168 Conn. 349, 362 A.2d 948 (1975), the court, ruling against a dredge and fill operation, stated that the "evils" of unreasonable pollution, impairment or destruction of the state's natural resources, were proper subjects for police power regulations. See also Potomac Sand & Gravel Co. v. Governor of Maryland, 266 Md. 358, 293 A.2d 241 (1972), cert. denied 409 U.S. 1040.

Preservation of the Environment: Ecosystems, Natural Resources, Habitat, Fish, and the Production of Nutrients: - There has been a major turnaround in the 1970s by the courts on behalf of the environment. The traditional public health, safety, and welfare focus on man alone has been broadened to include the role of man in the balance of nature. The federal cases which recognize not only the right, but the duty, of the Corps of Engineers to consider ecological factors in making decisions on dredge and fill permits are examples of this.

In United States v. Lewis, 355 F. Supp. 151 (1971), the court pointed to the importance of the productivity of the marshlands as a primary energy source, providing a basic unit in the food chain of sea animal life. It quoted a report which showed that a Georgia salt marsh can out-perform an average wheat field several-fold in organic production.

In Rivers Defense Committee v. Thierman, 380 F. Supp, 91 D.C.N.Y. (1974), the court found that irreparable injury could occur to spawning and nursery areas for many fish species as a result of fill (see also Zabel v. Tabb, and U.S. v. Joseph C. Moretti, 331 F. Supp. 151 (S.D. Cal. 1971). In Sands Point Harbor, Inc. v Sullivan, 346 A.2d 612 (1975), the New Jersey court held that regulation of the use of marshes and wetlands which have environmental and ecological importance to the continued existence of species and to mankind is a valid exercise of governmental power.

Conclusions

The most common constitutional attack on State (or local government) laws is the prohibition against taking without just compensation. In upholding such laws, courts couch their decisions in terms of public harms which are being prevented, rather than public benefits which are being obtained. Almost any impact can be viewed from either side of the coin--retaining a wetland can be seen as preventing the loss of a natural resource, or gaining a flood retention pond for the benefit of the general public. Federal laws, on the other hand, are vulnerable to the attack that they are beyond the authority granted to Congress in the U. S. Constitution. Once Federal authority is upheld, such as in the U. S. Army Corps of Engineers dredge and fill cases, the courts can cite the public benefits which the law sought to attain. State courts (and Federal courts when acting on State and local regulations) tend to cite benefits to be obtained. In either situation, there is no doubt that the present overall judicial thrust in the United States is to uphold floodplain regulations based on an ever-expanding array of economic, social, and environmental justifications.

APPENDIX B

DETAILED METHODOLOGY

Chapter II contained an explanation of the general rationale of and procedures for conducting empirical research based on a case study approach. It also outlined how the literature on effects and their evaluation and measurement was incorporated into the analytical methodology used in this research. Chapter II also presented the rationale and framework for using scenario analysis to project the effects of regulatory alternatives.

The detailed presentation of this material can be found in the "Task B Report" of this research which was submitted in January 1977. That report comprised the presentation and assessment of the methodologies selected for each major element of the research. These included:

- identification, classification and screening of effects;
- modes of measuring effects;
- scenario analysis, projection methodology and aggregation of data for their national implications;
- selection of a representative sample of case study communities; and
- procedures for conducting case studies, including survey instruments, data collection formats, and projection of effects formats.

The "Task B Report" also contained a detailed review and assessment of the literature on evaluating effects that is more detailed than that presented in Chapter II.

APPENDIX C

REAL ESTATE TRANSACTIONS IN THE FLOODPLAINS OF BERGEN COUNTY

The tables that follow are a compilation of a detailed examination of the effects of floodplain regulations on the values of floodplain properties in selected areas in Bergen County, New Jersey. They trace the values of floodplain properties bought and sold between 1974 and 1977. Conclusions are presented in Chapter IV, pages 118-121.

Tables C-1 through C-3 list the sales index ratios for floodplain properties that changed hands in Ridgewood (12 September 1975 through 19 July 1977), Glen Rock (1976 and 1977), and Oradell (1974 through 1977), respectively. A ratio less than 100 indicates that the sales price was higher than the assessed value (e.g., a ratio of 70 means the selling price was 30 percent higher than the assessed value). Conversely, a ratio greater than 100 indicates that the sales price was lower than the assessed value. It generally holds that the higher the ratio, the more recent the assessment. Table C-3 shows that selling prices for floodplain properties were substantially higher than assessed values than they were for all properties in the area. This could indicate that selling prices are rising faster in floodplains than in other areas.

Table C-4 compares sale prices with original asking price for floodplain properties that changed hands in Glen Rock for which this information was available. In addition, appraised values (which were calculated independent of any flood hazard or flood regulation factors) are presented where available. These indicate that whereas selling prices were usually below the original asking price, they nevertheless were higher than or as high as appraised values.

Table C-5 compares original and current (reduced) asking prices for properties on the market in northwest Bergen County.

The identification and inclusion of both hazard and nonhazard area properties allows the reductions in each of these areas to be compared. Thus it can be determined whether reductions in asking prices for floodplain properties are greater than, similar to, or less than reductions for nonhazard area properties for sale.

Table C-1: SALES INDEX RATIOS FOR RIDGEWOOD FLOOD PLAIN PROPERTIES

1975 SALES

BLOCK	LOT	DATE OF SALES	1973 MAP	PRELIM MAP	RATIO
1913	1-1	9/12/75		X	73
2803	2	12/23/75	X		60
2905	12	7/10/75	X	X	70
2906	13	3/4/75	X	X	60
2906	16	10/29/75	X	X	68
2906	18	9/5/75	X	X	60
3103	5	3/20/75	X	X	69
3102	3	4/30/75		X	57
3102	5	8/12/75		X	60
3104	2	1/09/75		X	60
3104	4	6/30/75		X	61
3104	33	11/24/75		X	66
3105	21	10/30/75		X	53
3201	42	12/10/75	X	X	66
3201	16	6/16/75		X	65
3202	1	7/17/75 1		X	68
3203	6	7/28/75	X	X	65
3204	15	11/7/75		X	56
3405	11	9/13/75	X	X	65
3405	18	4/4/75	X	X	69
3405	32	10/04/75	X		65
3505	9	4/9/75	X		
3505	11	6/25/75	X	X	69
3505	27	3/21/75	X	X	68
3505	41	7/18/75	X		66
3607	4	6/30/75	X	X	73
3607	6	7/15/75	X	X	64
3607	24	11/18/75	X	X	69
3611	11	5/8/75		X	56
3612	38	10/31/75	X	X	62

Table C-1--Continued

1975 SALES (cont)

BLOCK	LOT	DATE OF SALES	1973 MAP	PRELIM MAP	RATIO
4004	5	7/15/75	X		66
4004	7	3/15/75	X		64
4014	1	6/30/75		X	80
4015	11	7/12/75		X	58
4105	25	4/24/75		X	58
4106	29	6/30/75	X		102
4107	22	10/27/75	X	X	77
4205	17	8/27/75	X	X	56
4205	39	11/20/75	X		94
4312	4	1/30/75	X	X	71
4312	9	8/26/75	X	X	76
4314	2	2/3/75	X	X	66
4314	3	5/7/75	X	X	61
4315	5	9/12/75	X	X	59
4317	5	6/12/75	X	X	65
4318	10	5/28/75	X	X	67
4404	6	8/19/75	X	X	70
4504	13	11/12/75		X	61
4505	1	10/1/75		X	63
4505	34	8/11/75		X	67
4505	34	9/4/75		X	64
4605	9	3/17/75		X	73
4609	3	10/16/75		X	65
4609	7	1/13/75		X	1
4609	15	10/29/75		X	60
4609	25	5/30/75		X	58
4707	1	9/30/75		X	74
4707	9	6/5/75	X	X	74
with 4708	1		X	X	
4707	11	5/20/75	X	X	71
4802	5	7/9/75	X	X	81
	[illegible]	[illegible]		X	62

Table C-1--Continued

1976 SALES

BLOCK	LOT	DATE OF SALES	1973 MAP	PRELIM MAP	RATIO
1913	15	1/30/76		X	61
1914	2	8/16/76		X	51
2507	4	2/2/76		X	66
2507	7	7/15/76		X	60
2508	6	7/31/76	X	X	53
2508	13	11/3/76	X	X	51
2509	3	6/13/76		X	50
2704	7	11/19/76	X		45
2803	7	8/6/76	X		60
2905	17	6/4/76	X	X	63
3101	2	8/16/76	X	X	59
3103	5	8/3/76		X	54
3104	35	12/10/76		X	58
3106	24	7/26/76		X	60
3201	28	10/14/76		X	55
3203	8	2/27/76	X	X	65
3203	10	8/10/76	X	X	63
3202	29	8/20/76		X	51
3311	19	4/17/76	X	X	75
3505	13	8/30/76	X	X	62
3505	35	6/23/76	X		64
3601	14	4/22/76		X	62
3607	9	11/18/76	X	X	63
3607	11	2/11/76	X	X	54
3607	26	3/12/76	X	X	73
3613	8	6/17/76		X	63
4005	28	8/16/76	X		57
4013	10	8/04/76	X		56
4013	11	7/5/76	X		57
4015	8	11/16/76	X		50
4106	7-1	4/1/76	X	X	65

Table C-1--Continued

1976 SALES (cont)

BLOCK	LOT	DATE OF SALES	1973 MAP	PRELIM MAP	RATIO
4106	10	1/21/76	X		
4106	16	8/12/76	X		65
4106	21	11/1/76	X		43
4106	23	5/18/76	X		64
4106	28	9/15/76	X		62
4107	11	4/26/76	X		62
4205	15	7/15/76	X	X	55
4205	28	9/17/76	X		64
4205	34	10/25/76	X		61
4305	22	7/15/76	X		59
4311	9	7/16/76		X	68
4312	7	2/24/76	X	X	65
4313	13-1	8/20/76		X	74
4314	5	6/23/76	X	X	61
4318	9	8/6/76	X	X	59
4405	17	10/22/76	X	X	60
4406	1	7/22/76	X	X	64
4406	2	7/22/76	X	X	73
4407	2	3/5/76		X	136
4502	29	2/27/76		X	68
4503	5	7/14/76		X	68
4503	25	11/16/76		X	59
4504	12	6/18/76		X	69
4504	18	6/16/76		X	69
4505	10	10/20/76	X	X	
4505	22	5/28/76		X	54
4609	8	7/2/76		X	56
4707	30	5/12/76	X	X	57

Table C-1--Continued

1977 SALES

				(Map Not Adapted)	
BLOCK	LOT	DATE OF DEED	1973 MAP	PRELIM MAP	RATIO
1906	6	3/24/77		X	58
2508	11	2/31/77	X	X	63
2905	26	7/18/77	X	X	58
3107	18	3/1/77	X	X	64
3104	17	7/18/77		X	66
3104	18	/2/77		X	76
3106	25	4/22/77		X	58
3201	6	7/15/77	X	X	60
3201	29	6/10/77		X	55
3201	39	4/28/77	X	X	69
3201	46	5/27/77	X	X	56
3305	4	1/27/77	X	X	75
3405	32	3/22/77	X		
3505	23	2/23/77	X		59
3607	18	2/16/77	X	X	51
3607	40	3/30/77	X	X	45
4005	22	6/28/77	X	X	57
4015	3	2/19/77	X		62
4106	22	5/17/77	X		56
4205	24	7/18/77	X	X	57
4205	35	2/4/77	X		59
4317	4	7/26/77	X	X	64
4318	10	6/29/77	X	X	54
4503	24	5/6/77		X	52
4503	25	4/6/77		X	59
4504	12	3/8/77		X	62
4505	13	1/20/77		X	60
4605	3	2/7/77		X	50
4705	8	5/27/77		X	60
4802	2	7/19/77	X		71

Table C-2:

BOROUGH OF GLEN ROCK

FLOOD ZONE SALES
1976 and 1977

BLOCK	LOT	ADDRESS	SALE DATE	1977 ASSESSED VALUE	SALE PRICE	SALES RATIO
33	10	291 Dunham Pl.	4/6/76	$119,600	$115,000	104.00
64	24/25	225 Boulevard	5/11/76	64,000	63,500	100.78
33-B	18	373 Dunham Pl.	6/4/76	98,200	95,500	102.83
64	13	175 Boulevard	6/7/76	70,700	77,900	90.77
35	12	25 Diamond Ct.	7/9/76	63,300	66,000	95.91
64	2	129 Boulevard	7/29/76	63,300	62,500	101.28
32	13	121 Rutland Rd.	8/3/76	109,200	89,000	122.70
33-B	22	339 Dunham Pl.	8/6/76	110,500	112,000	98.66
64	31	251 Boulevard	10/13/76	53,800	52,000	103.46
55	7/8	21 Brook Pl.	10/27/76	63,900	68,000	93.97
64	8-A	155 Boulevard	2/15/77	78,300	71,000	110.28
43	7	18 Concord Ave.	4/28/77	69,500	84,900	81.86
55	17	93 Boulevard	7/20/77	72,900	103,000	70.78
55	21	111 Boulevard	7/29/77	69,100	81,500	84.79
						97.29 AVERAGE

Table C-3:

FLOODPLAIN SALES IN ORADELL, NEW JERSEY
1974 - 1977

Address	Block	Lot	Assessed Value	Selling Price	Date of Sale	Ratio	County Ratio
949 Amaryllis	245	12-15	67,100	74,000	6-27-74	90.67	109.29
788 Village	161-B	8	57,700	64,000	4-8-74	90.15	109.29
799 Village	161-A	8	64,300	77,000	7-15-74	83.50	109.29
916 Amaryllis	241 d 244	25-A 29	59,700	74,000	10-10-74	80.67	109.29
996 Woodland	254	1	70,000	81,500	10-3-75	85.88	97.82
968 Midland	247	52-55	89,000	101,000	10-7-75	88.11	97.82
952 Woodland	245	78-81	64,700	68,000	6-9-75	95.14	97.82
956 Woodland	245	74-77	55,600	62,500	11-25-75	88.96	97.82
801 Midland	229	5-10	57,400	61,500	9-12-75	93.33	97.82
731 Park	214	79-81	46,900	54,000	5-23-75	86.85	97.82
685 Blauvelt	206-D	11	113,800	130,000	10-2-75	87.53	97.82
212 Essex	153	8A-10	50,400	60,000	2-18-75	84.00	97.82
782 Martin	152	26-29	60,800	64,000	9-24-75	95.00	97.82
276 Essex	152	7-8	40,800	51,000	5-30-75	80.00	97.82
801 Midland	229	5-10	58,900	68,800	10-29-76	85.61	92.04
773 Park	214	58-60	52,500	65,500	10-5-76	80.15	92.04
635 Baluvelt	206-D	6	106,600	112,500	1-14-76	94.75	92.04
793 Sherwood	160-E	7	56,900	71,500	6-29-76	79.58	92.04
201 Essex	155	17-20	60,800	69,500	7-22-76	87.48	92.04
784 Oradell	229	37-40	59,400	78,000	7-8-77	76.15	88.47

Table C-4: LISTINGS OBTAINED FROM APPRAISER/REALTOR IN GLEN ROCK

Community	Sales Price	Appraised Value	Original Asking
654 Brookside, Allendale	$ 60,900	$ 57,000	$ 62,900
111 Boulevard, Glen Rock	81,500		97,500
20 Rock Lodge, Salle River	295,000		311,000
728 Lenwook, Ridgewood	63,900	63,000	66,900
128 Lakeshore, Oakland	53,500		53,500
204 Sallas Court, Ridgewood	90,000		97,400
114 Roosevelt, Oakland	55,900		57,900
384 Vesta Ct, Ridgewood	61,900	61,000	61,900
68 Trumen, Oakland	58,000		61,900
384 W.Shore Dr., Wyckoff	131,500	128,000	134,500
76 Island Terrace, Oakland	21,000		21,000
321 Brookside, Allendale	58,450		58,900
37 E. Glen Ave., Ridgewood	75,000		86,900
224 Burnside, Ridgewood	175,000	175,000	
767 Paramus Rd, Paramus	81,000		94,500*
120 W. Oakland Ave, Oakland	49,900		30,000
131 Bergen Ct, Ridgewood	68,000		69,900
21 Clove Brook Rd, Mahwah	85,000		89,900
26 Twenbrook Ct., Ramsey	93,650		97,900

*Busy thorofare

Table C-5: COMPARISON OF ORIGINAL AND CURRENT ASKING PRICES FOR HAZARD AND NON-HAZARD AREA PROPERTIES IN NORTHWEST BERGEN COUNTY

	FLOOD PLAIN				
MAHWAH	YES	NO	NOT DESIGNATED	ORIGINAL	CURRENT
128 Ramapo Valley			X	54,900	49,900
5710 Airmount			X	58,900	56,900
168 Ridge		X		69,500	64,900
6 Karen Dr.			X	74,500	72,500
18 Beehive Ct			X	76,900	74.500
210 Orchard		X		84,500	83,500
253 Miller Rd			X	110,000	99,900
115 Glasgow Tr		X		117,500	112,500
81 Malcolm Rd		X		139,000 (134,900)	129,900
54 Vanderbeck Ln		X		145,000	138,200
Flamming_Arrow		X		125.000	159.900
RIDGEWOOD					
898 Best Ct		X		54,100	52,500
4755 Pleasant		X		56,000	54,500
1103 Ridgewood		X		62,900	59,900
313 Oak		X		64,500 (63,500) (61,900)	60,900
571 Grove			X	64,900	62,500
432 Stevens		X		65,900	63,900
233 Highwood			X	75,900	67,500
334 S. Van Dien		X		71,500	69,900
196 W Glen		X		74,900 (72,900_	69,900
529 Jemco		X		74,900	72,500
242 N. Pleasant		X		81,500 (79,000)	74,500

Table C-5--Continued

	FLOOD PLAIN				
	YES	NO	NOT DESIGNATED	ORIGINAL	CURRENT
418 Van Buren	X			54,900	-
234 E Glen	X			59,900 (58,500)	57,900
305 Eastside	X			64,500 (61,500)	59,900
488 Grove	X			71,900	68,900
338 James	X			69,900	-
379 Queens	X			91,500	-
706 Terhune	X			150,000	-
379 Wastena		X		89,900	86,900
253 Woodside		X		103,000	99,900
812 Parsons		X		119,500 (114,900)	109,900
751 Hillcrest		X		119,900	115,000
114 Glenwood		X		142,500 (134,500)	125,000
850 Parson		X		137,500	127,500
701 Howard			X	174,500	169,000
244 Lotte		X		206,000 (198,750)	189,000
HO HO KUS					
622 E. Saddle River	X			159,900	149,900
119 First		X		78,900	75,900
609 Ackerman		X		79,900	77,500
956 Valley Forge			X	79,900	77,900
Valley Stream Ln			X	105,000	99,900
5 Sargent Rd		X		139,500	137,500
215 Wearimus		X		250,000	140,000

Table C-5--Continued

	FLOOD PLAIN				
WYCKOFF	YES	NO	NOT DESIGNATED	ORIGINAL	CURRENT
271 Cedarhill	X			79,800 (77,000)	74,900
497 Goffle		X		49,900	48,900
476 Lincoln			X	69,900	67,500
87 Colgate Rd		X		77,900 (74,900) (73,000) (72,900)	71,900
369 Cedarhill		X		79,500	77,500
189 Schlena			X	89,500 (86,900) (85,900)	85,000
108 Elmwood		X		92,900	89,900
760 Hickory Hill		X		125,000 (105,000)	95,000
487 Elegene			X	119,900	109,900
44 Ravine		X		119,500 (115,900) (113,900)	109,900
40 Edgewood		X		115,000	112,000
434 Caldwell				121,900	117,900
269 Wyckoff		X		126,900	119,900
466 Massey Ct			X	127,900 (125,900) (120,500)	117,700
Deep Brook Rd			X	134,900	129,900
759 Frederick		X		179,000	174,900
UPPER SADDLE RIVER					
86 Old Stone Church Rd	X			129,900	-
60 Pleasant Ave	X			147,500	-
20 Old Stone Church	X			68,900	-
10 Old Stone Church			X	74,900	66,900

Table C-5--Continued

	FLOOD PLAIN				
UPPER SADDLE RIVER (cont)	YES	NO	NOT DESIGNATED	ORIGINAL	CURRENT
87 Pleasant		X		97,500	92,500
44 Timberlane		X		99,500	93,900
6 Hidden Glen			X	98,000	94,900
51 Old Stone Church		X		98,500	94,900
23 Sleepy Hollow			X	115,000	109,000
39 Cherry Lane			X	119,500	112,500
3 Winding Way		X		118,000	115,000
53 Skyline Dr			X	127,500	122,500
39 Cider Hill		X		132,900 (129,900)	124,900
31 Rambling Brook			X	139,900	129,900
39 Timberlane		X		139,900	134,500
66 Old Stone Church			X	148,000 (142,500)	139,900
27 Cider Hill		X		159,900	154,900
6 Valley Lane		X		167,900	157,900
37 Sunrise		X		199,000 (198,000) (196,000) (195,000) (194,000)	192,500
45 Hillcrest		X		212,750	199,000
6 Stonegate			X	215,000	199,000
SADDLE RIVER					
277 Mill Rd		X		159,900 (154,900)	149,750
42 Woodcliffe Lake		X		194,900	179,500
101 Fox Hedge		X		299,900	310,000
14 E Saddle River Rd		X		395,000	350,000

Table C-5--Continued

	FLOOD PLAIN				
OAKLAND	YES	NO	NOT DESIGNATED	ORIGINAL	CURRENT
6 A Riverside	X			11,900	-
6 Riverside Dr	X			12,800	11,500
49 Island Terr.	X			18,500	*21,500
9 Riverside	X			28,000	-
69 Island Terr.	X			35,000	-
23 Acorn	X			37,000	-
36 A & 36 B Riverside	X			38,500 (2 houses)	-
51 Lakeview	X			39,900	-
33 River Rd	X			47,900 (45,900)	42,900
7 Hillside	X			44,900	-
38 & 40 Riverside	X			49,900 (2 houses)	-
155 Franklin		X		51,900 (49,900)	48,500
31 Walnut			X	54,900	53,000
31 Minnehaha		X		55,900	53,500
50 Sioux		X		58,000	53,900
23 Rockaway	X			54,900	-
93 Roosevelt			X	58,500 (56,500)	54,900
26 Sioux		X		59,000 (57,000)	56,000
18010 Oakland		X		61,900 (59,900)	57,900
46 Powder Mill		X		61,900	59,900
100 Truman		X		63,900 (61,900)	60,900
12 Hawatha		X		61,900	60,900
84 Grove		X		64,900 (63,400)	62,900
20 Loyola		X		65,900	63,900
Pool Hallow Rd			X	99,900 (92,500)	87,000
3 Pequot			X	125,000	117,000